GOES-R AWG Product Validation Tool Development

Imagery Application Team

Tim Schmit (STAR)
With help from many others

OUTLINE

- **Products** (1-2 slides)
- **Validation Strategies** (3-4 slides)
- **Routine Validation Tools** (4-5 slides)
- **"Deep-Dive" Validation Tools** (4-5 slides)
- **Ideas for the Further Enhancement and Utility of Validation Tools** (1-2 slides)
- **Summary**

Products

- The purpose of the imagery team is two-fold:
  - Demonstrate how to convert from GRB scaled radiances (eg, GRB integers) to other physical units, such as radiance, brightness temperatures and brightness values.
  - Build files that can be used for processing most all of the ABI products, such as clouds, soundings, etc.

- Imagery is the key product for GOES-R.

- There are 54 KPP Cloud and Moisture Imagery End-Products (CMIP) (48 single band End-Products in netCDF format at the resolution native to each band and one multiband product at 2 km resolution in both netCDF & McIDAS Area file formats).
  - 16 products * 1 format (netCDF) * 3 coverage areas (Full Disk, CONUS, Mesoscale) Multiband products: 1 product * 2 formats (netCDF and McIDAS Area)* 3 coverage areas (Full Disk, CONUS, Mesoscale)

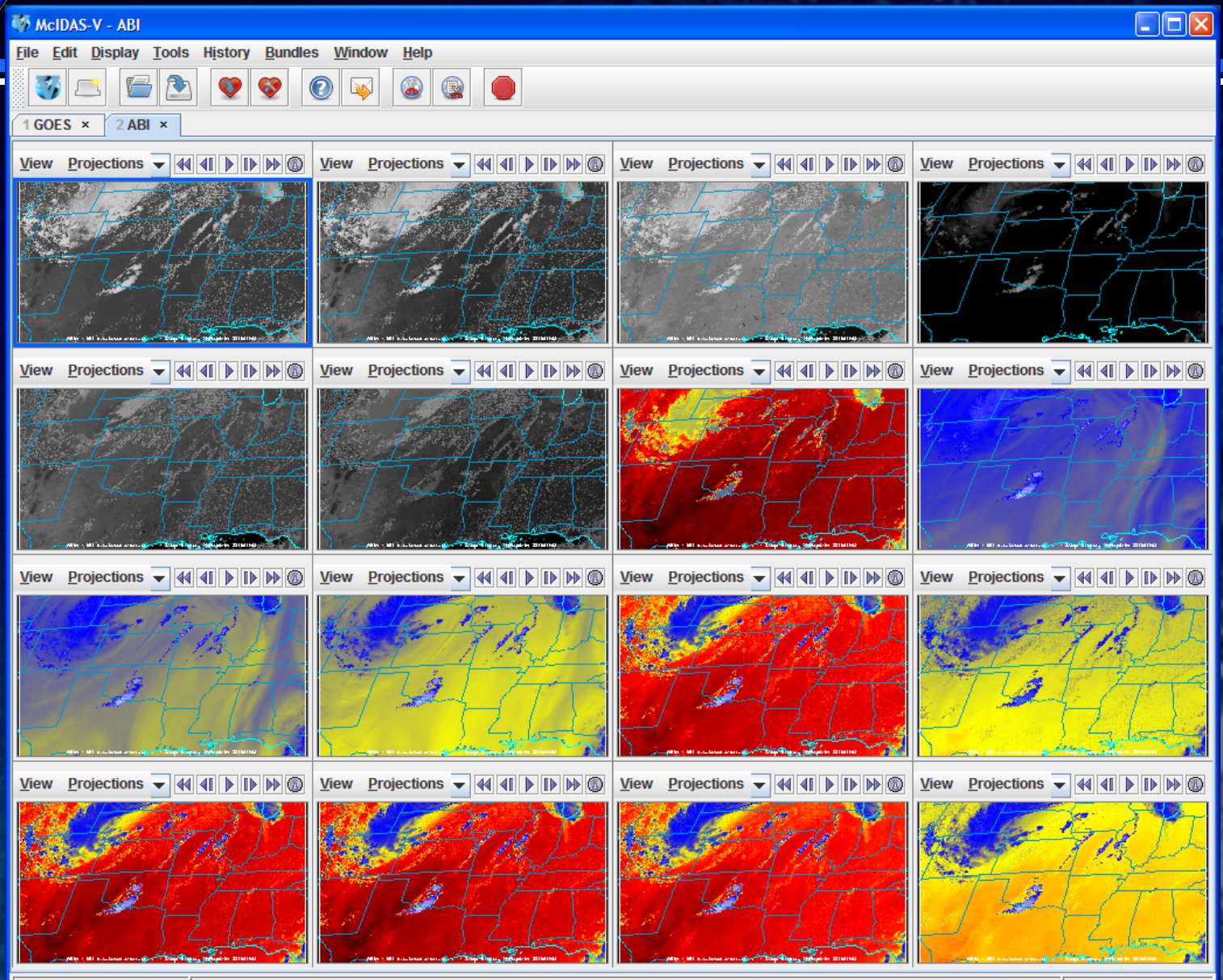
ABI Band Characteristics

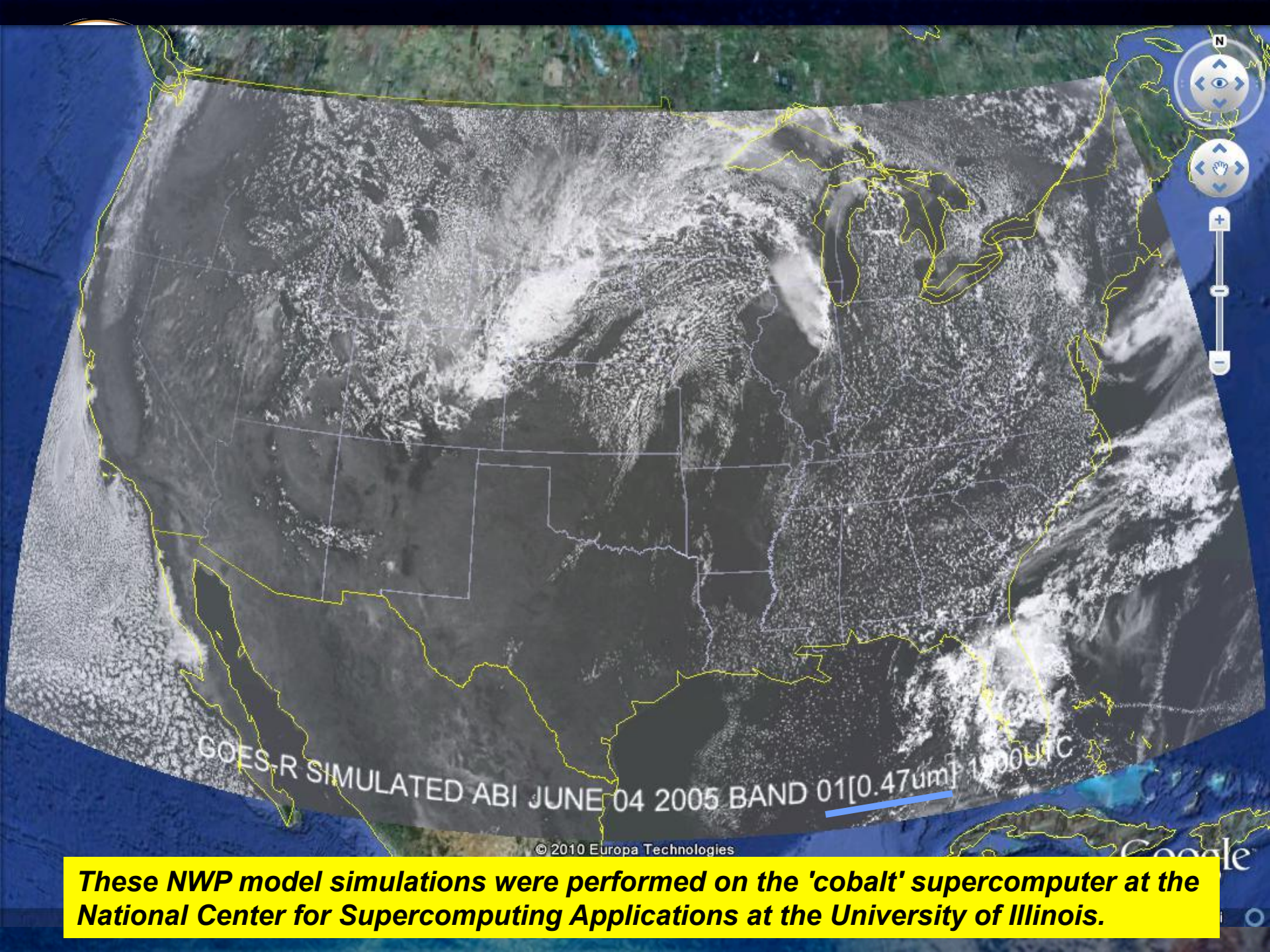
Band #	Central Wavelength (um)	Spatial Resolution (km)	Bit-Depth (Recommended)	Used in Cloudy and Moisture Imagery
1	0.47	1	12	Yes
2	0.64	0.5	12	Yes
3	0.86	1	12	Yes
4	1.38	2	12	Yes
5	1.61	1	12	Yes
6	2.26	2	12	Yes
7	3.9	2	14	Yes
8	6.15	2	12	Yes
9	7.0	2	12	Yes
10	7.4	2	12	Yes
11	8.5	2	12	Yes
12	9.7	2	12	Yes
13	10.35	2	12	Yes
14	11.2	2	12	Yes
15	12.3	2	12	Yes
16	13.3	2	12	Yes

Reflective bands

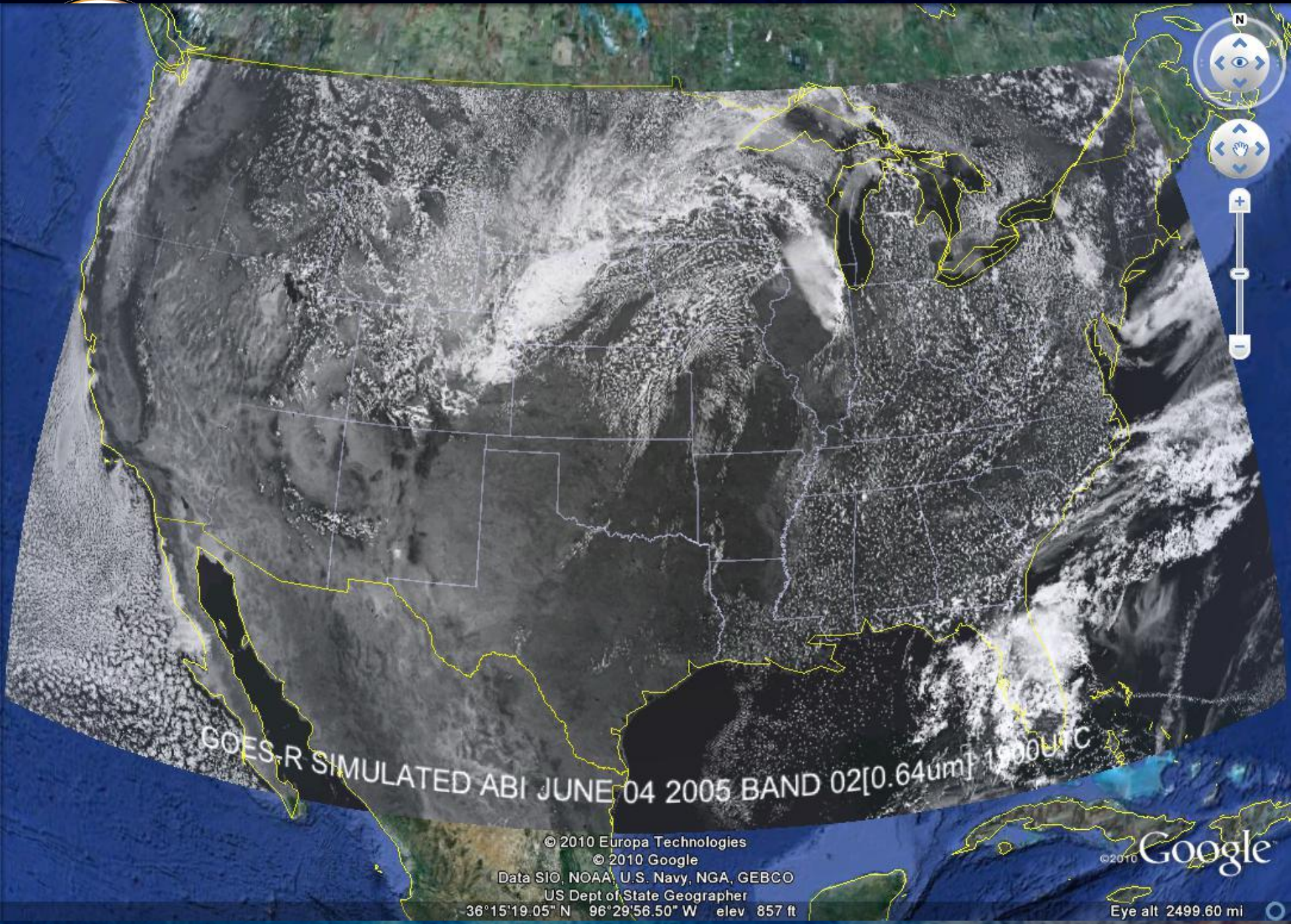
Emissive (IR) bands

Example CMIP Output ABI bands in McIDAS-V





These NWP model simulations were performed on the 'cobalt' supercomputer at the National Center for Supercomputing Applications at the University of Illinois.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US Dept of State Geographer
36°15'19.05" N 96°29'56.50" W elev 857 ft
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Eye alt 2499.60 mi


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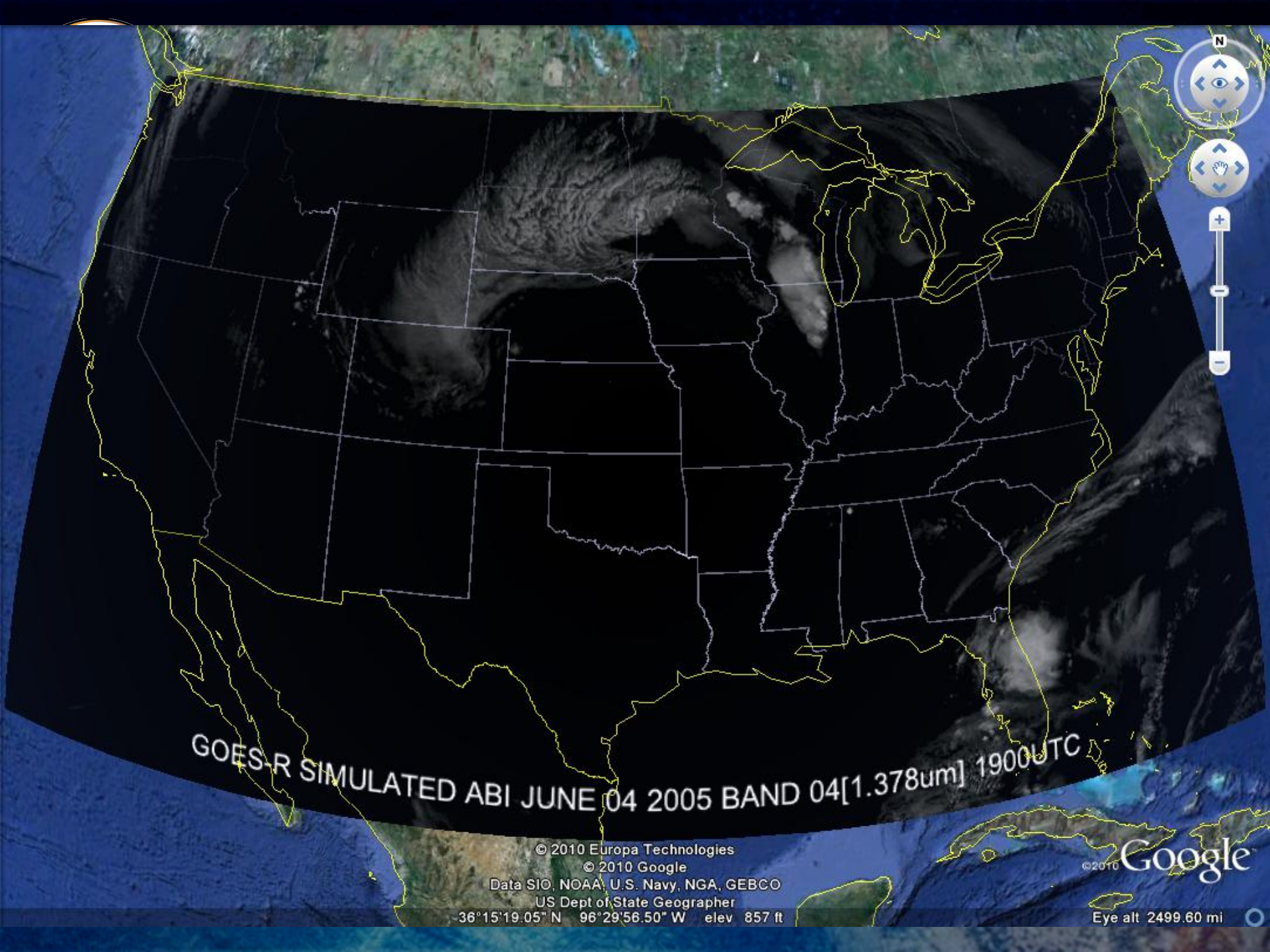
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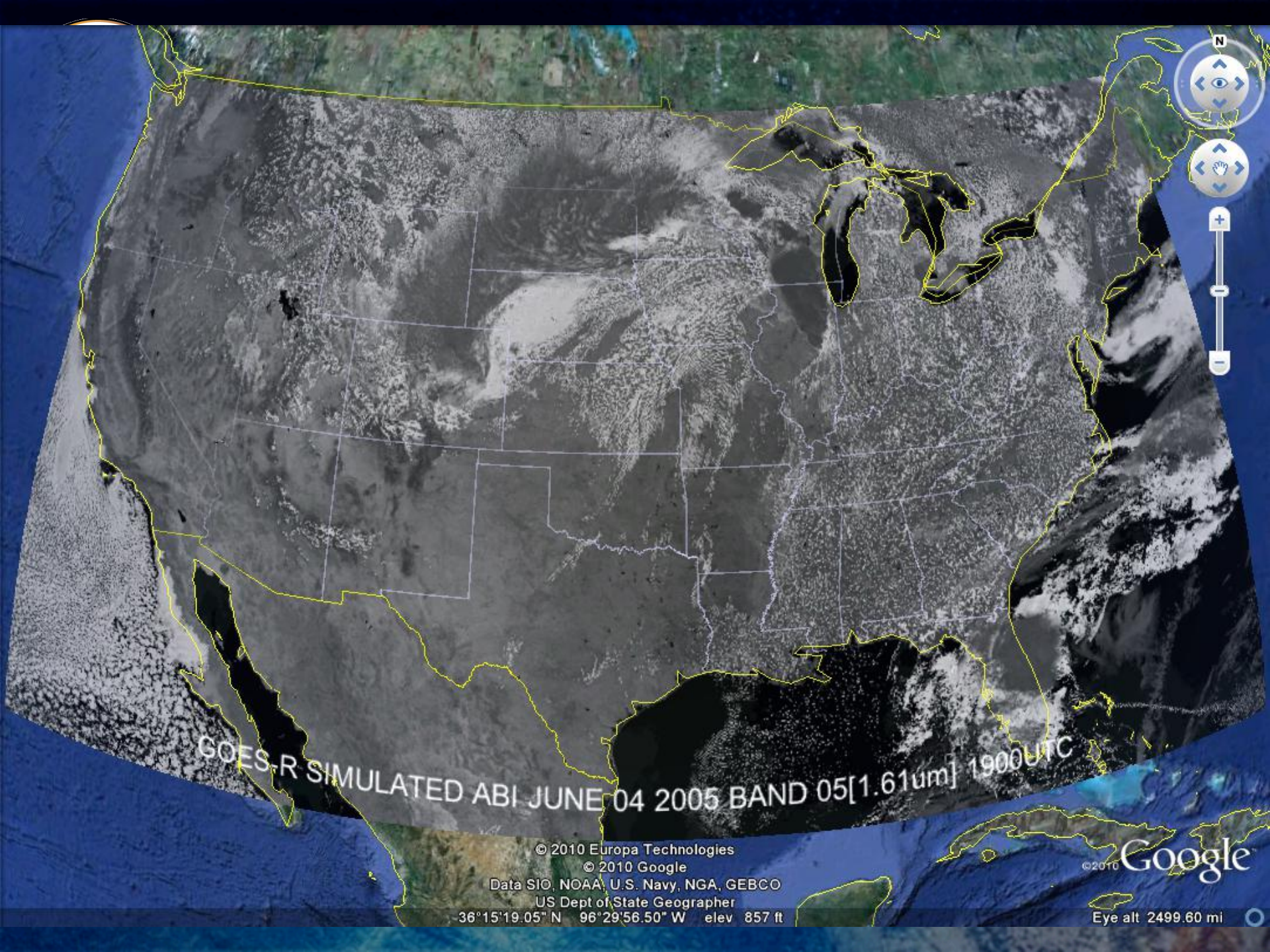
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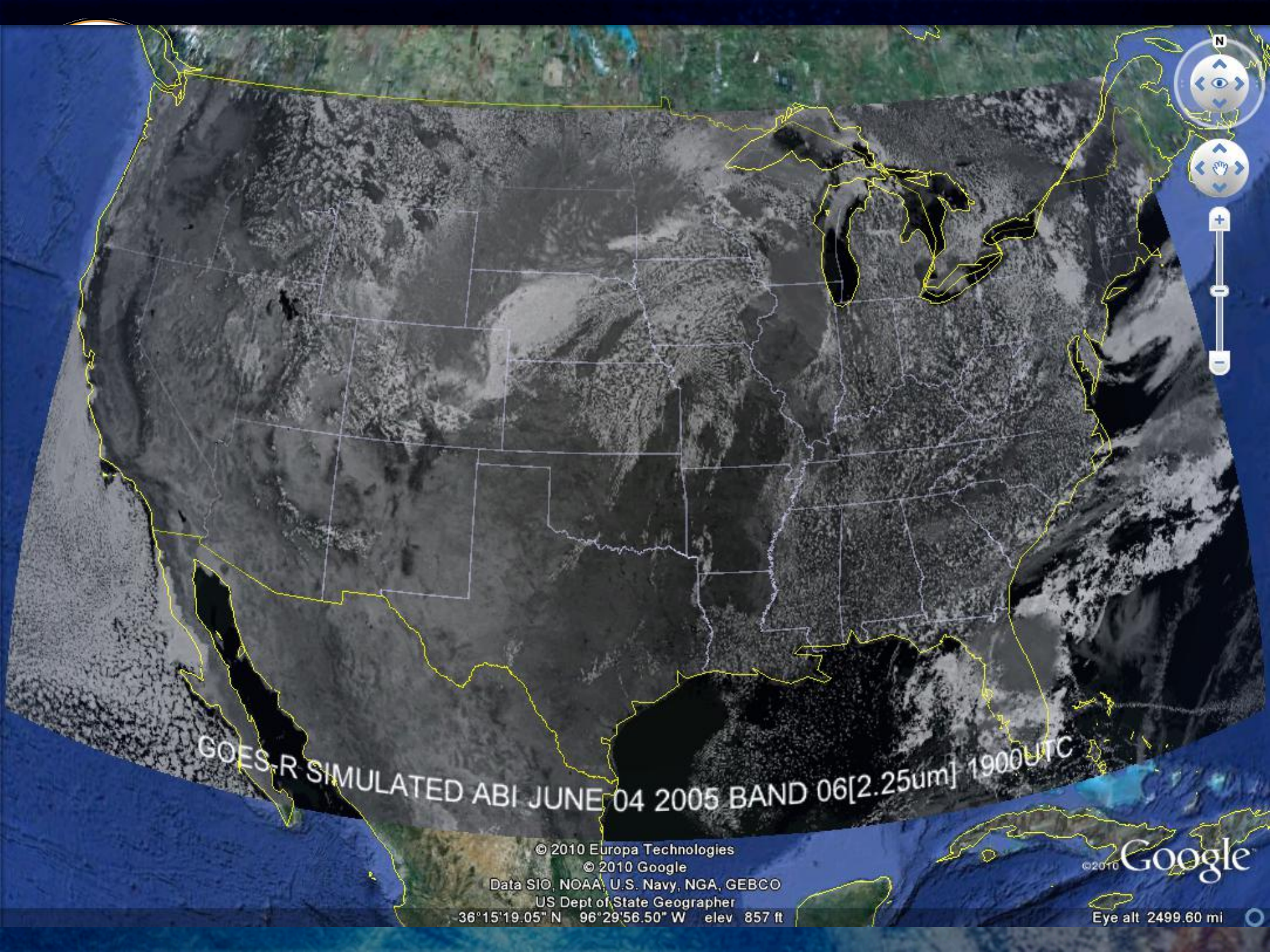
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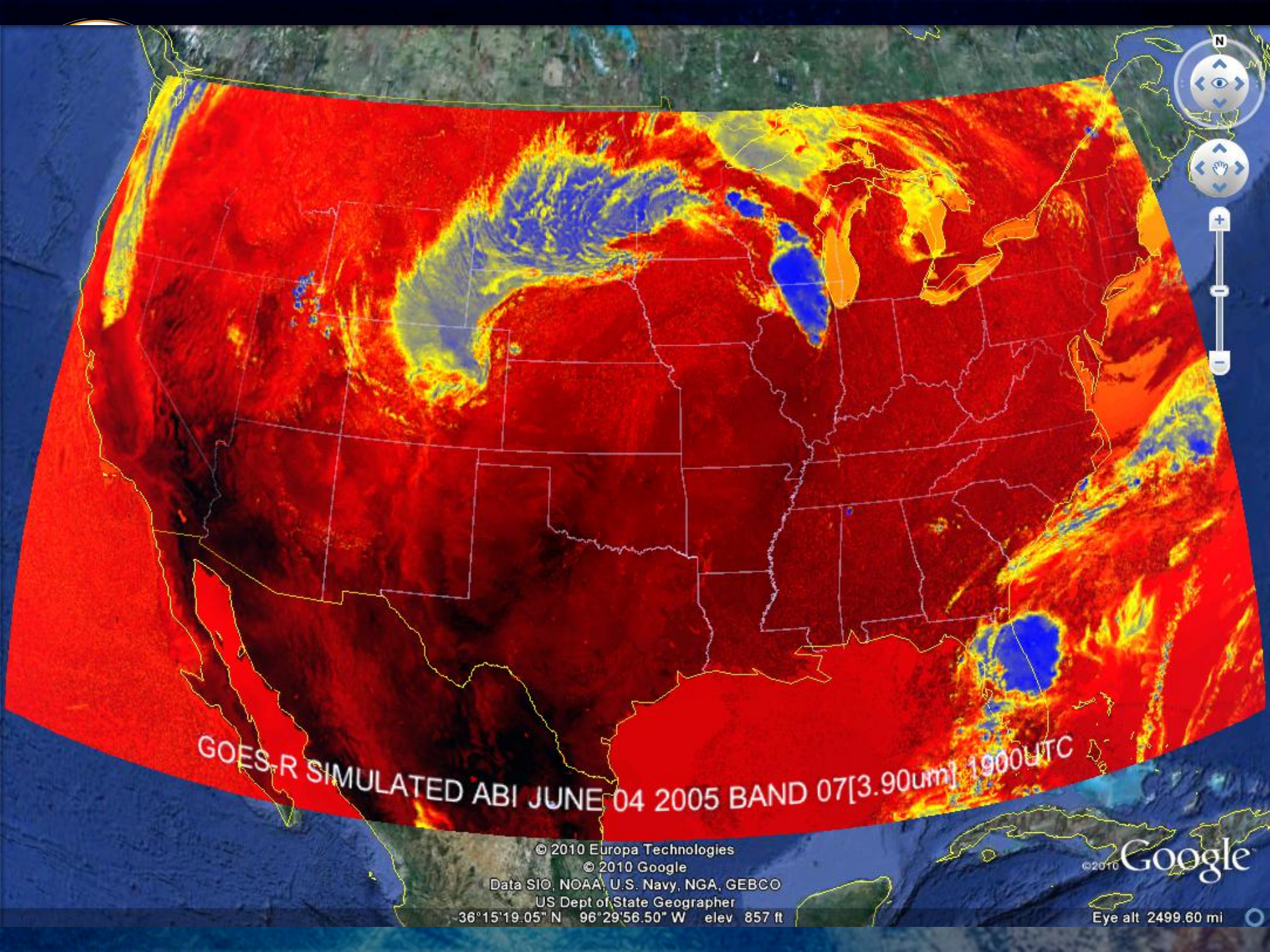
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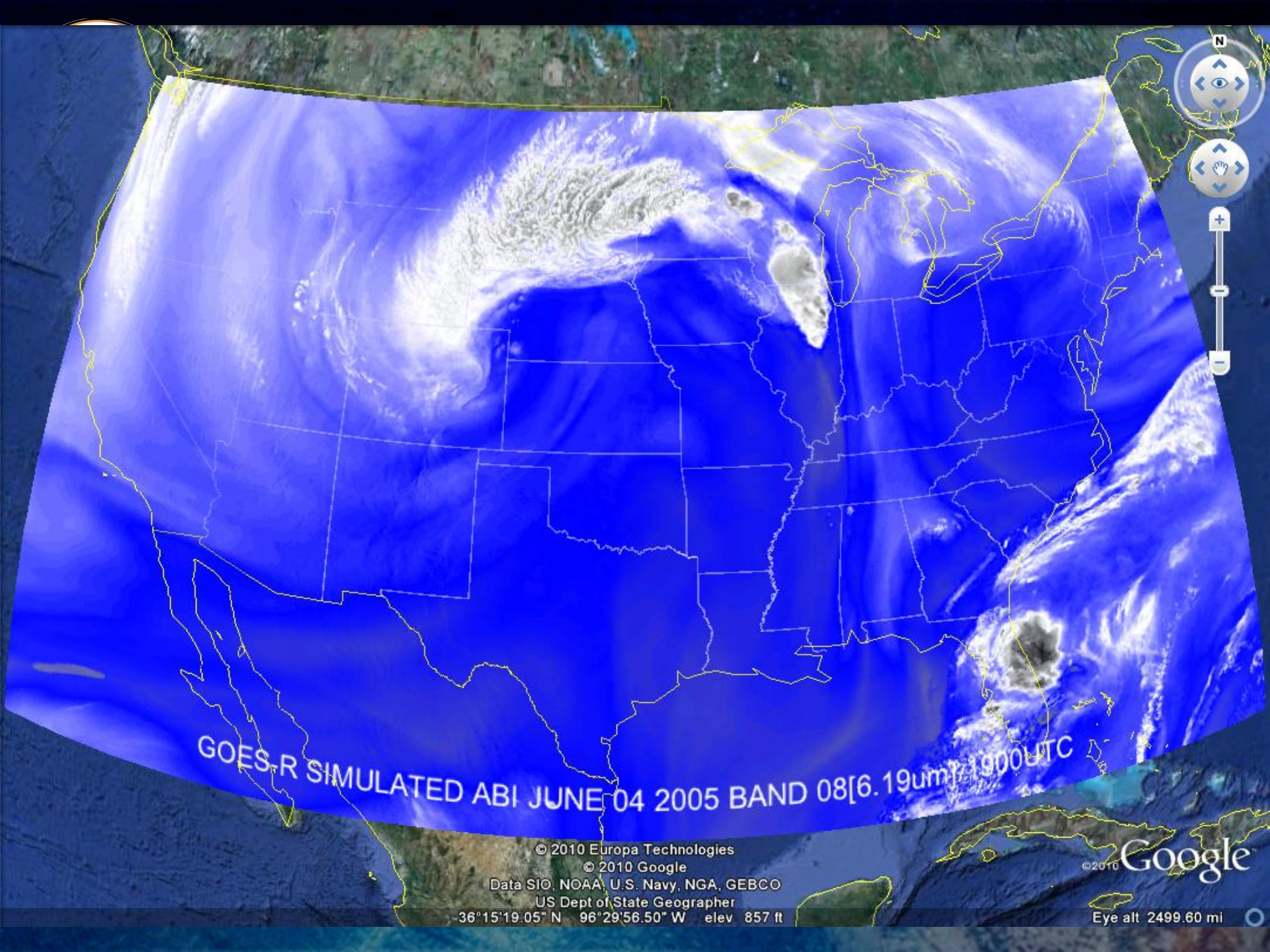
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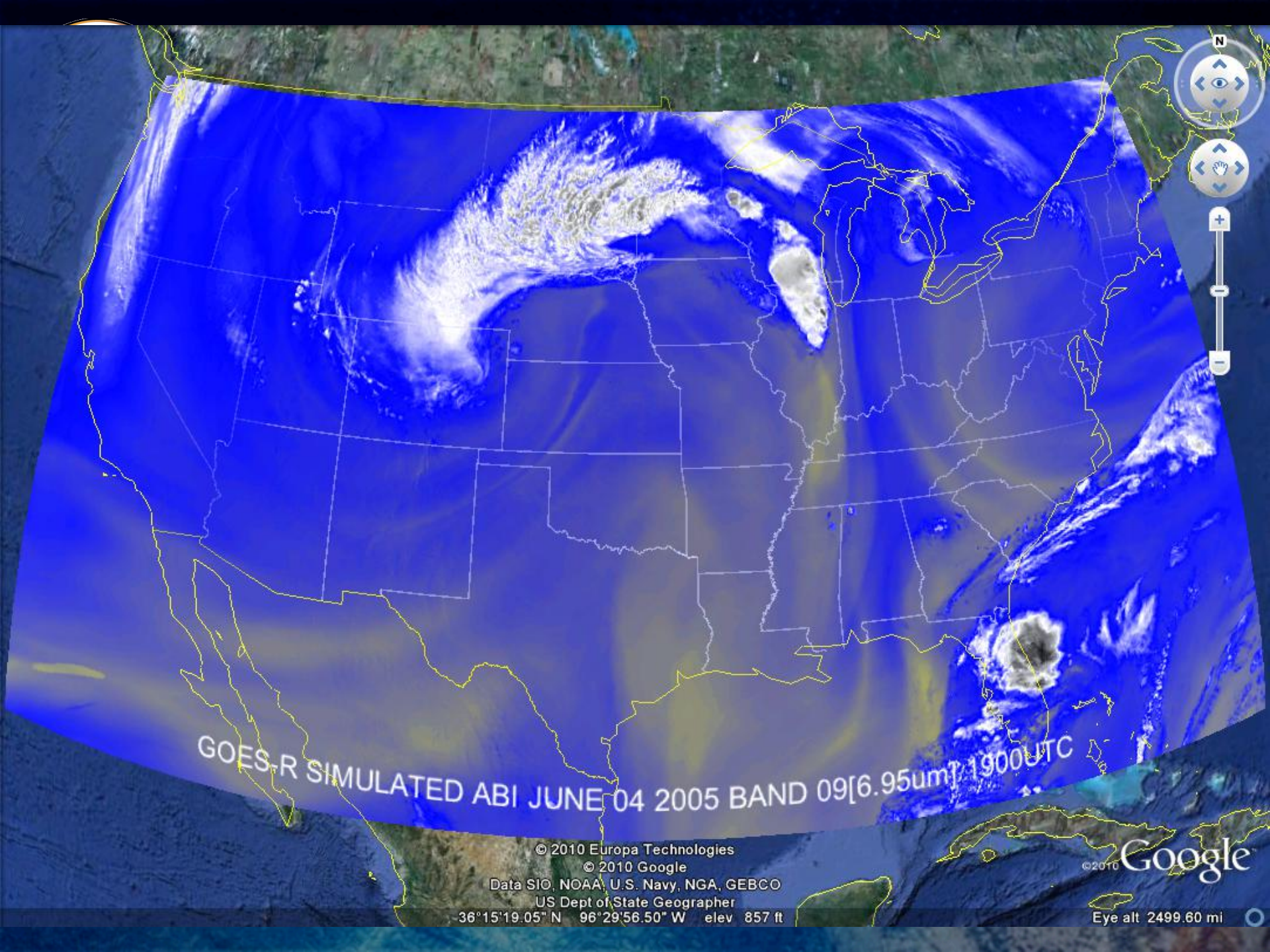
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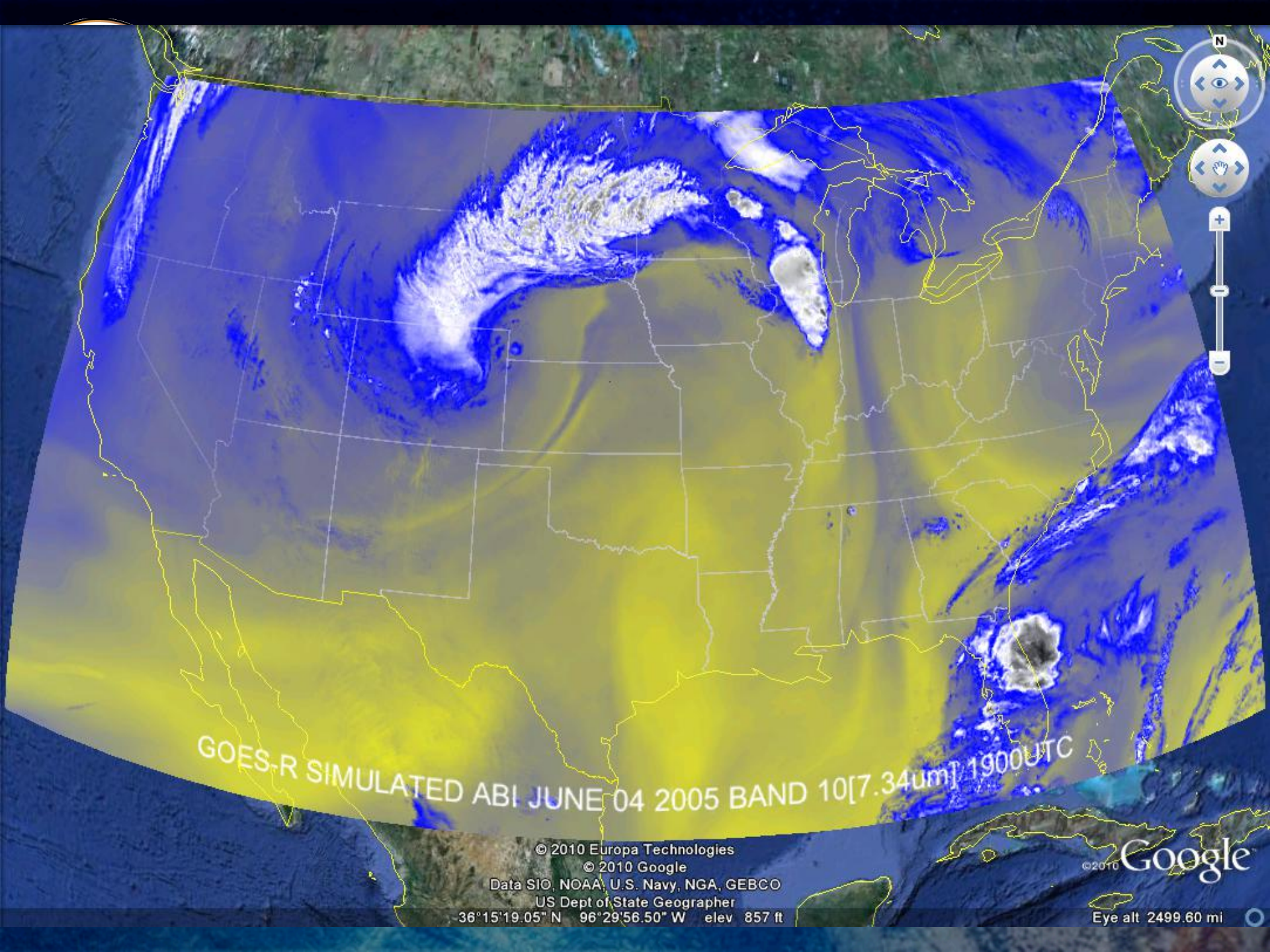
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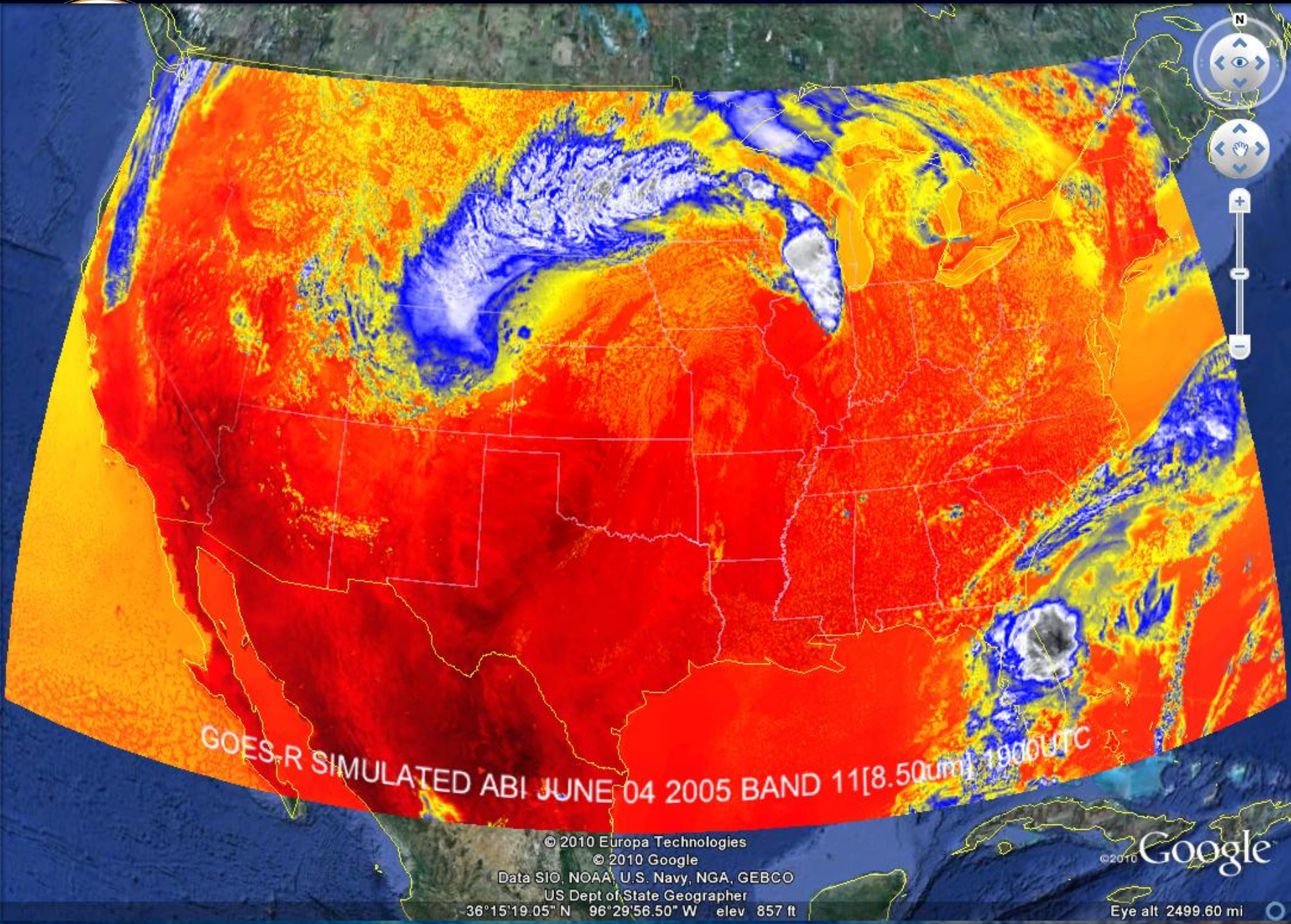
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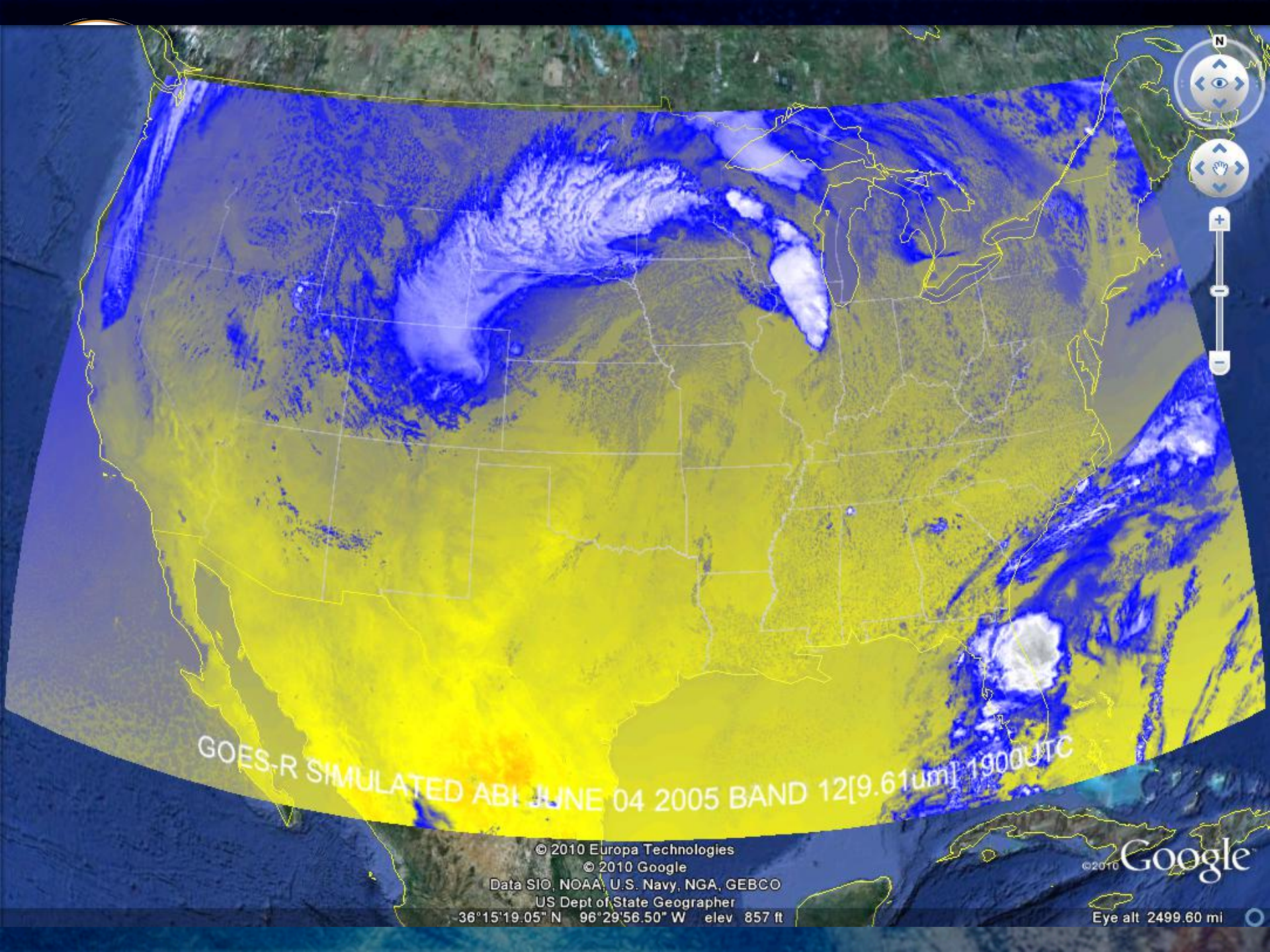
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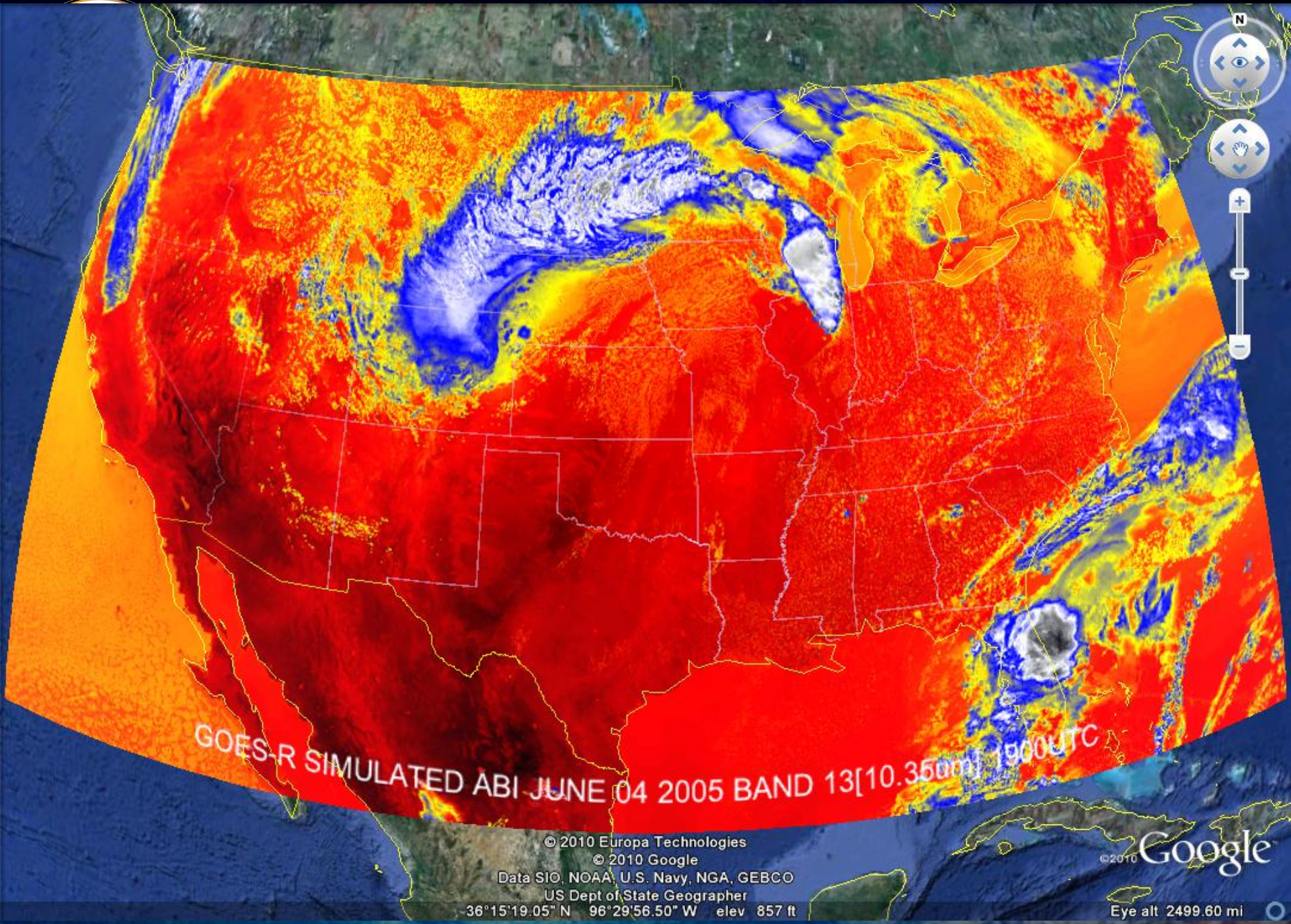
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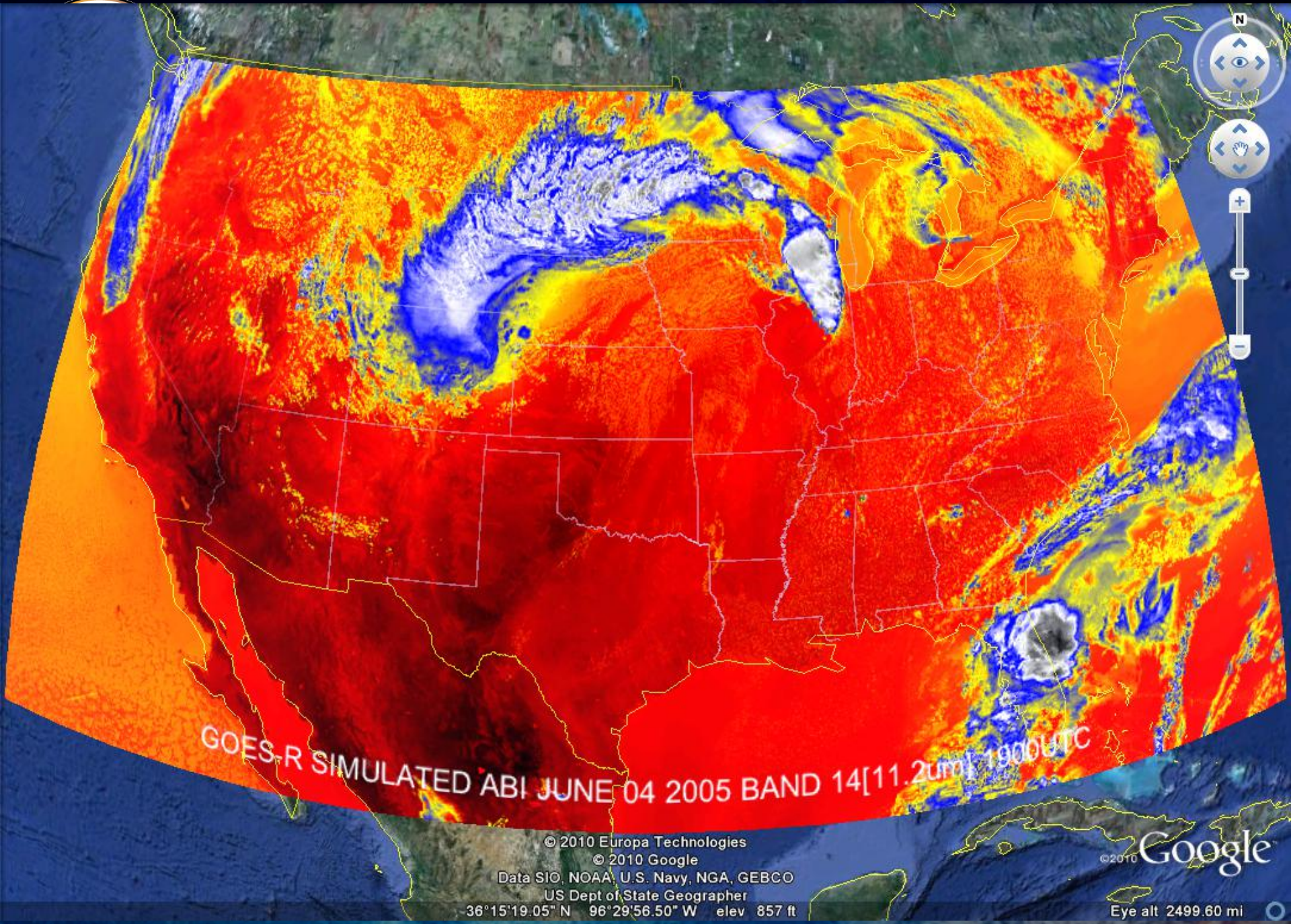
Eye alt 2499.60 mi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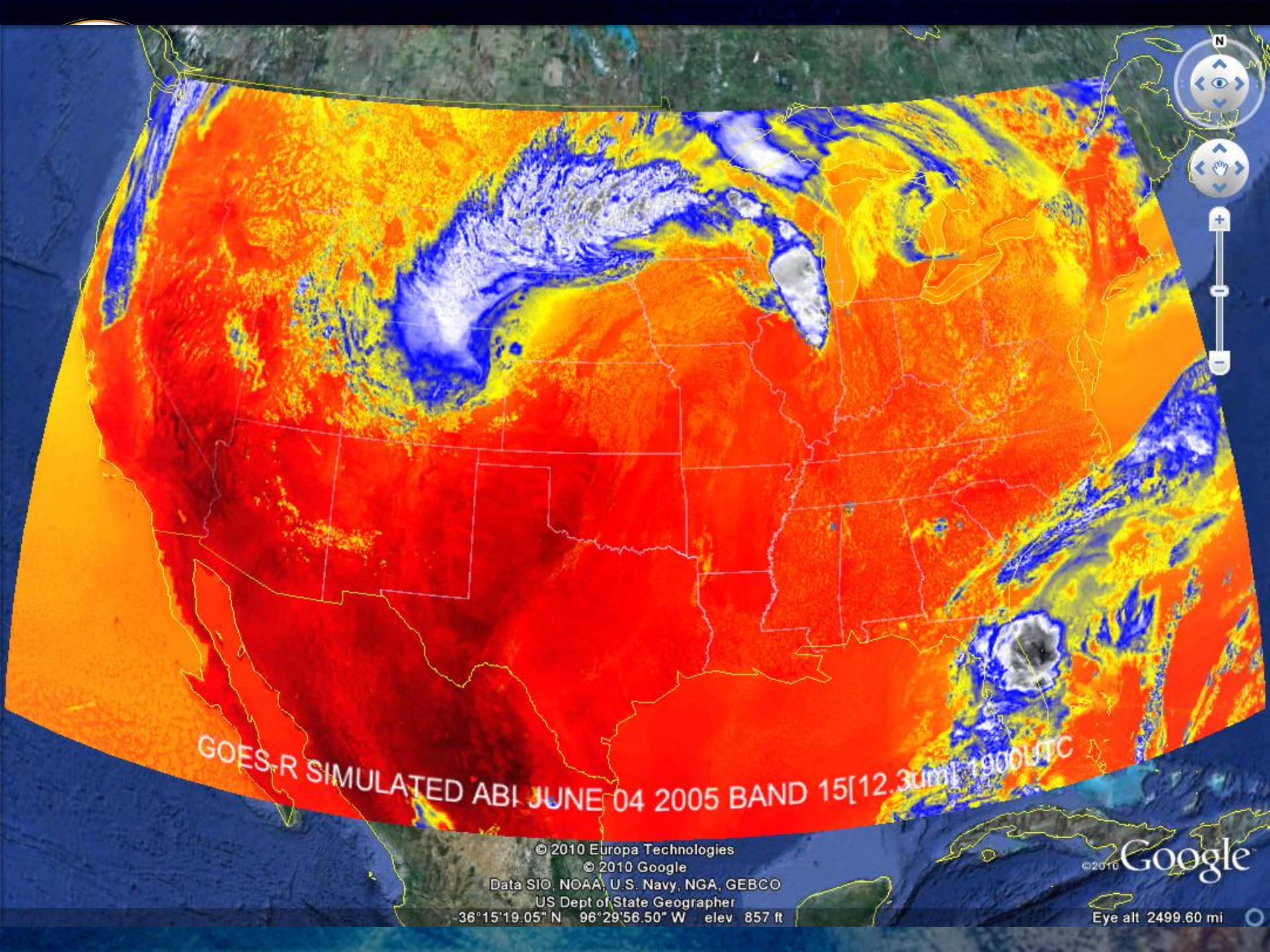
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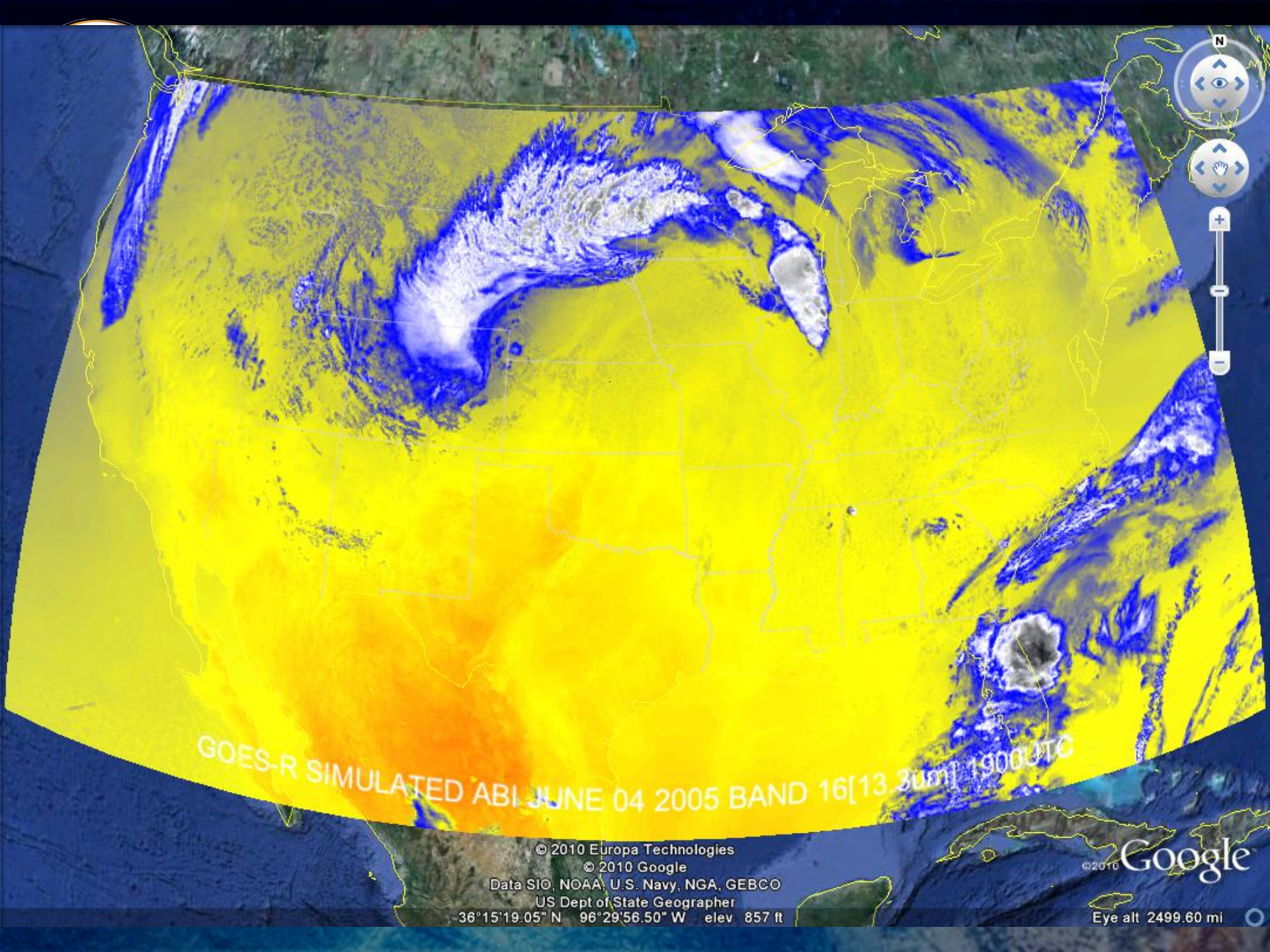
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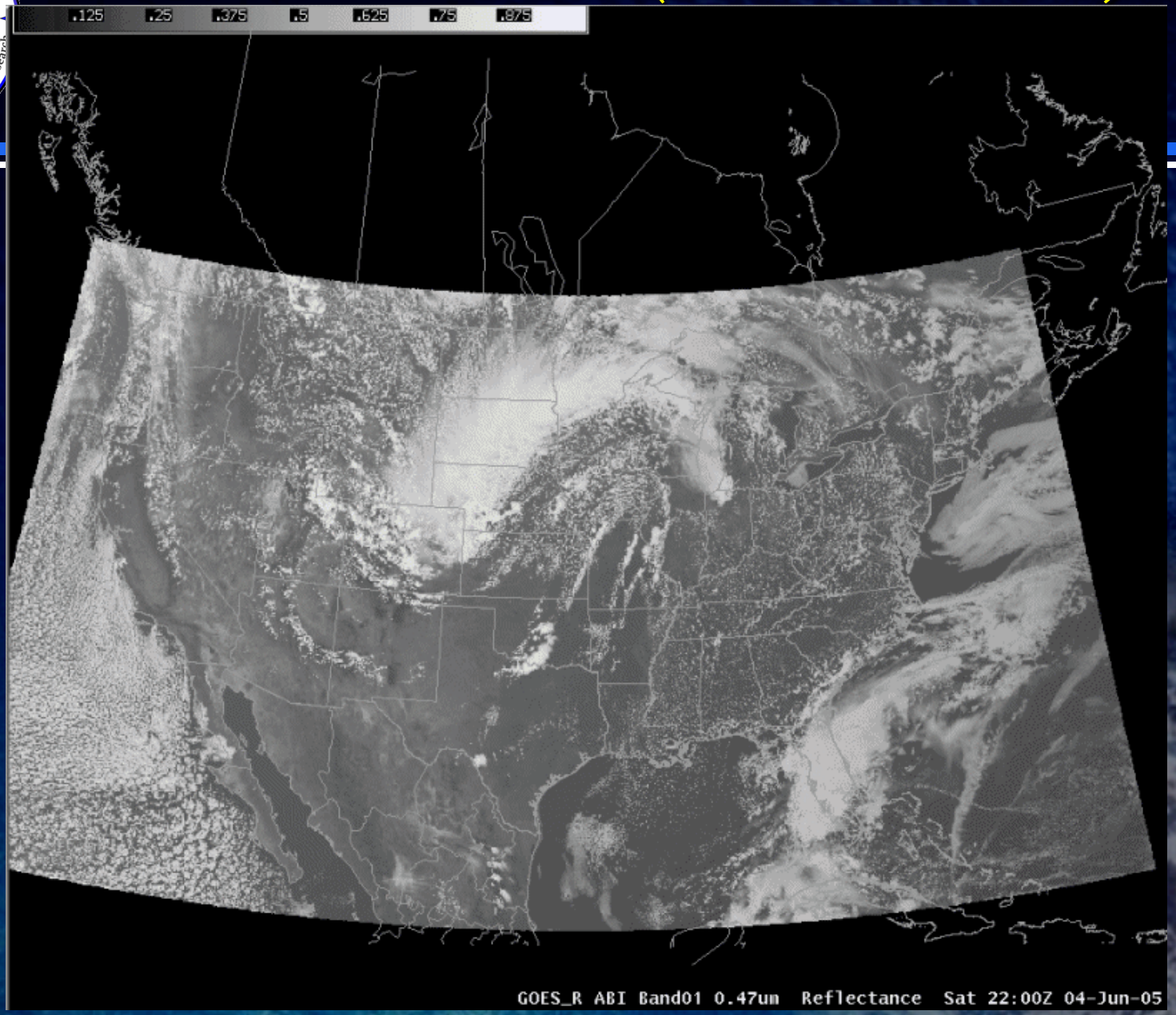
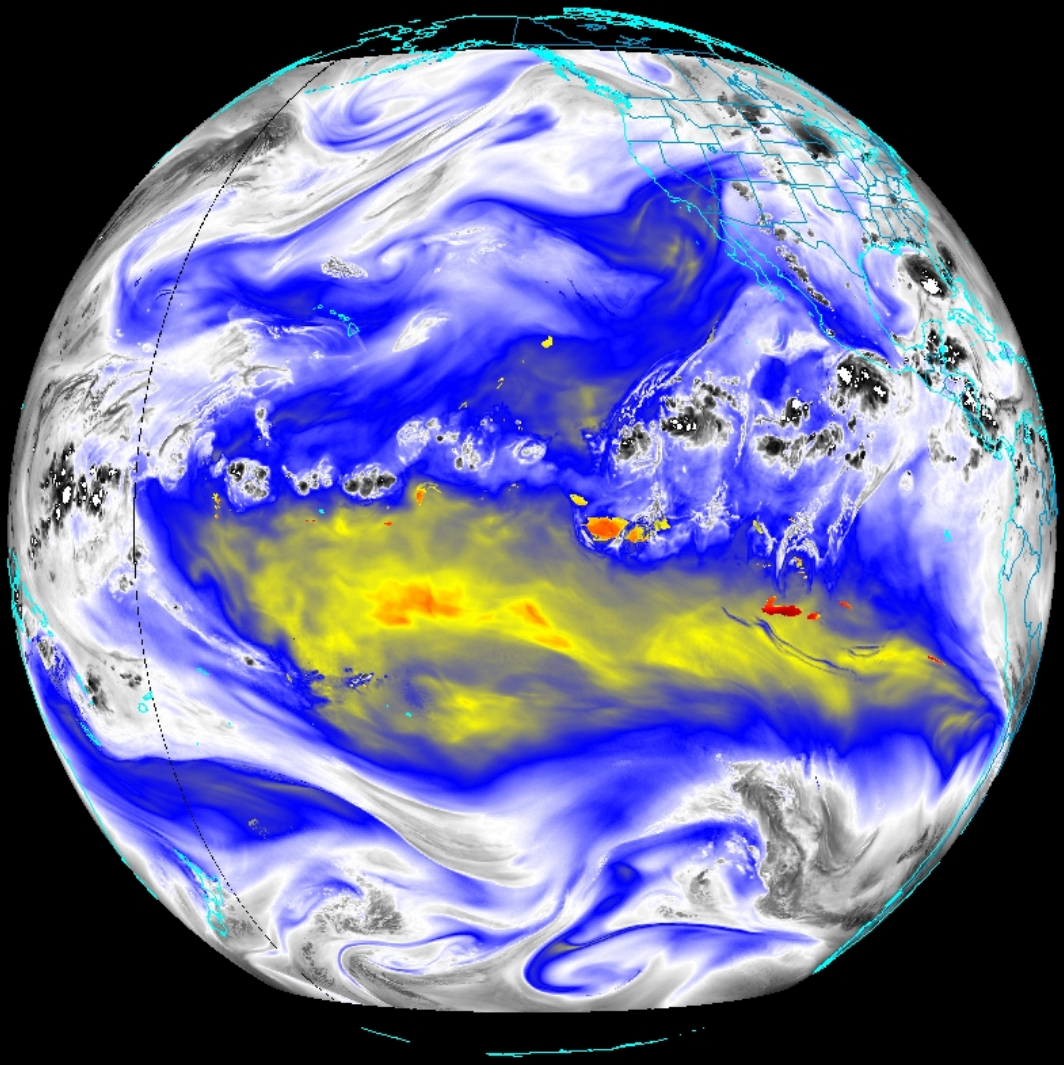
ABI in AWIPS (via netCDF)



Proxy Team; J. Oktin et al., CIMSS

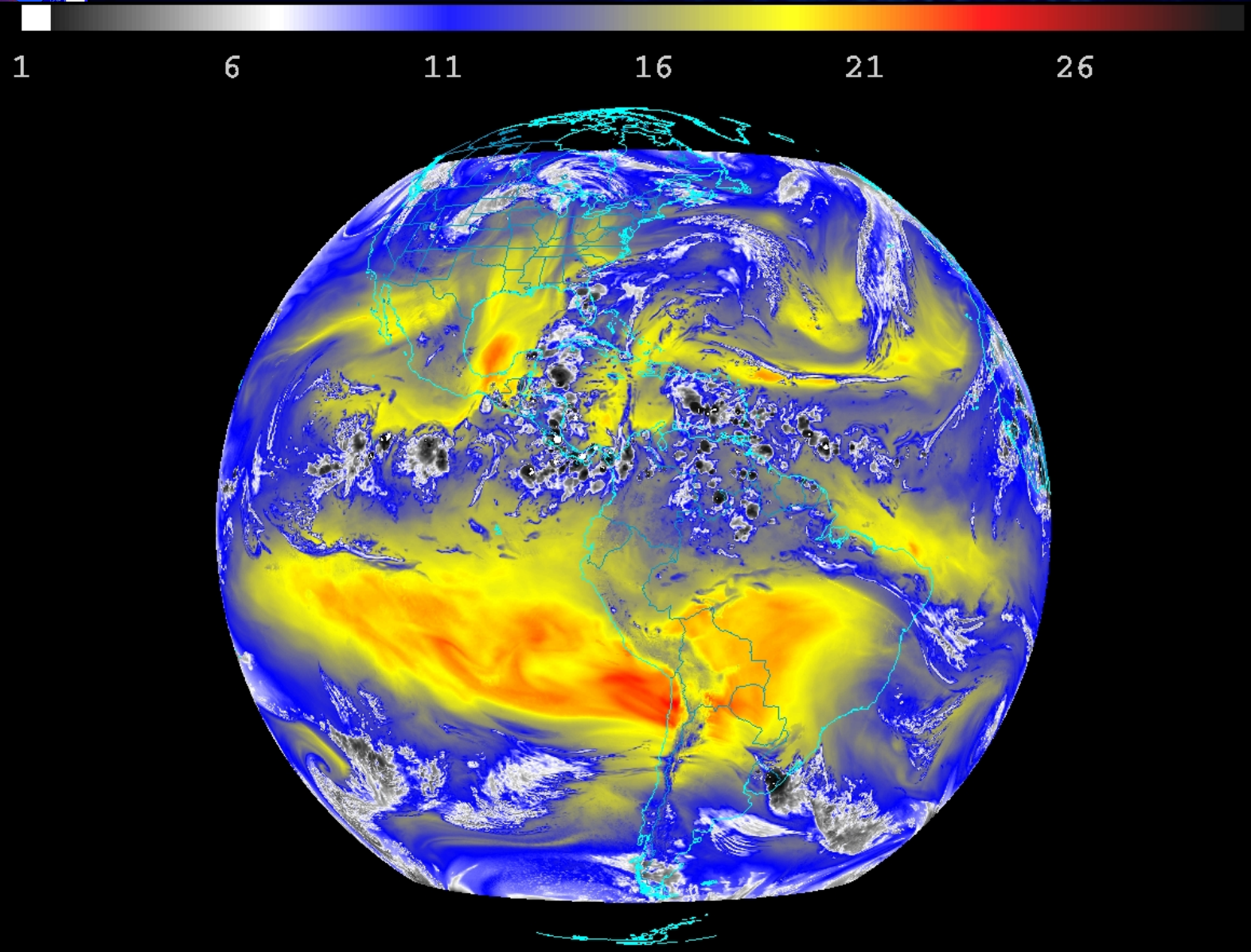
Simulated Advanced Baseline Imager (ABI) bands shown; in the legacy AWIPS.

In ABI FGF (137W)



WRF Simulation - 6.15 um Radiance - GOES-R WEST (137W)

In ABI FGF (75W)



WRF Simulation - 7.4 um Radiance - GOES-R EAST (75W)

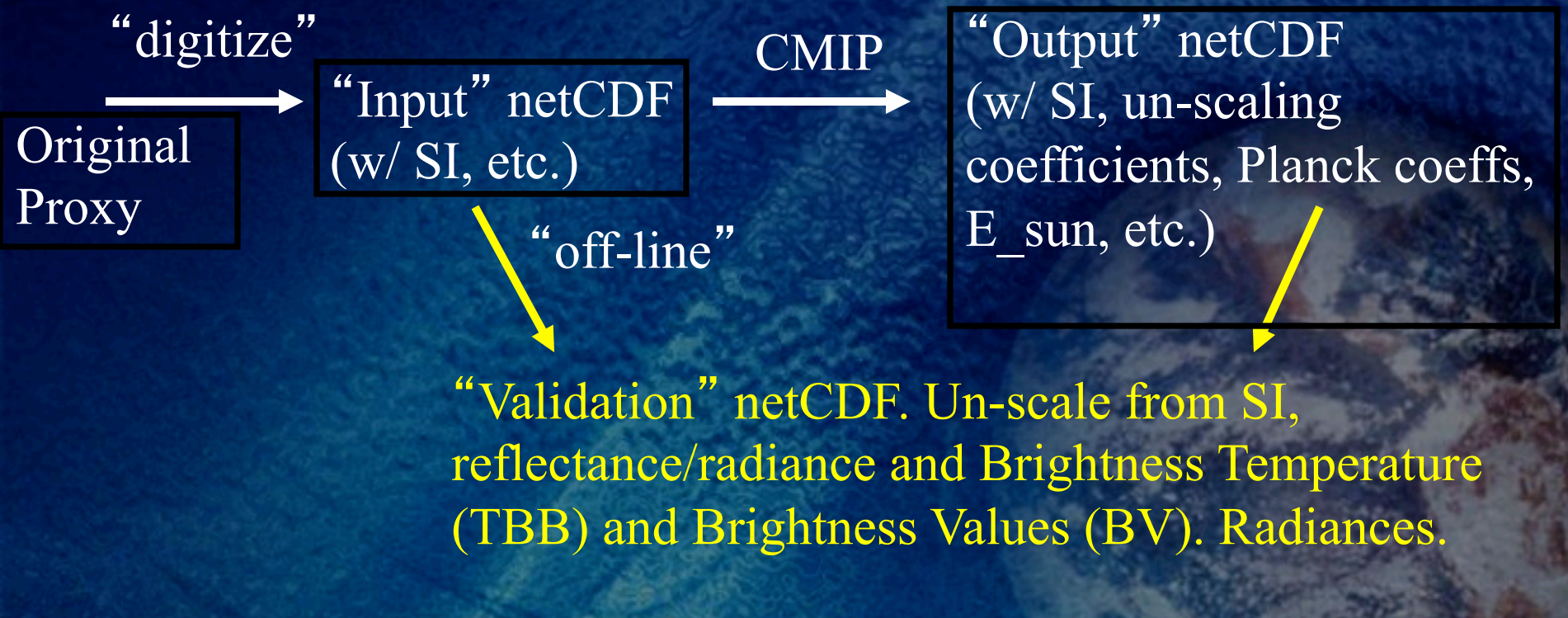
Validation Strategies

- Compare GRB values to “CMIP” values to ‘close the loop’.
- Generate a host of images
- Animations
- Generate zoomed images
- Generate difference images
  - Temporal
  - Spectral
- Monitor “forward model calc” vs “satellite obs”
- Monitor image quality
- Compare to other imagery (eg, VIIRS, etc.)
- Inter-calibration (eg, GSICS)
- Have a flexible, yet powerful, system to “query” the data
- Combine images
- Product generation!

Some of these fall under the calibration or system monitor groups!

Validation

Imagery does not have traditional 'truth' datasets for comparison, such as radiosondes or aircraft data. In light of this, we have defined our own 'truth' data via high resolution NWP runs, coupled with advanced forward modeling.



Routine Validation Tools

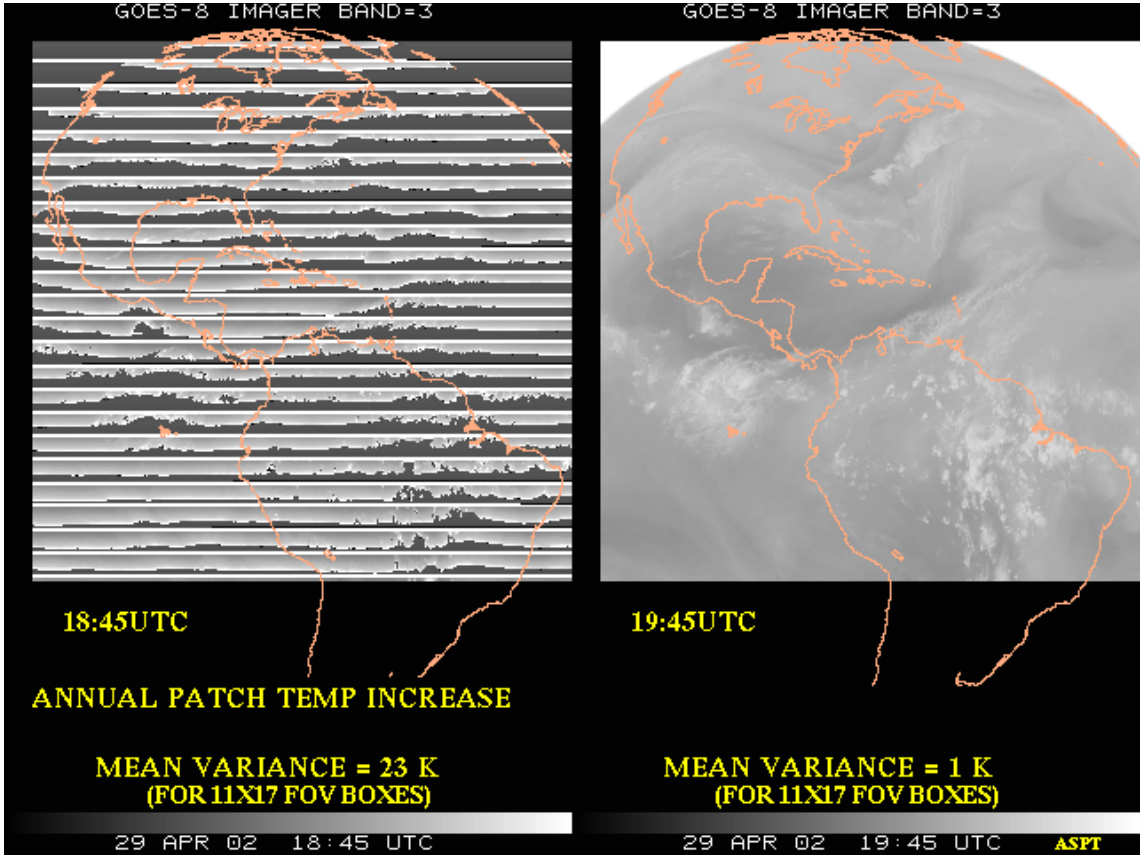
This tool set includes, but is not limited to:

- Time series of radiances/brightness temperatures
- Statistics of radiances/brightness temperatures
- Generate a host of images, thumbnail images
- Animations
- Generate zoomed images
- Monitor “forward model calc” vs “satellite obs”
- Monitor image quality
- Compare to other imagery (e.g., VIIRS, etc.)
- Etc.
-
-

Average of valid data samples
Number of valid data samples
Minimum value of valid data samples
Maximum value of valid data samples
Sum of valid data samples
Sum-of-squares of valid data samples
Total number of data samples within the sample set

Brightness Temperature Variance

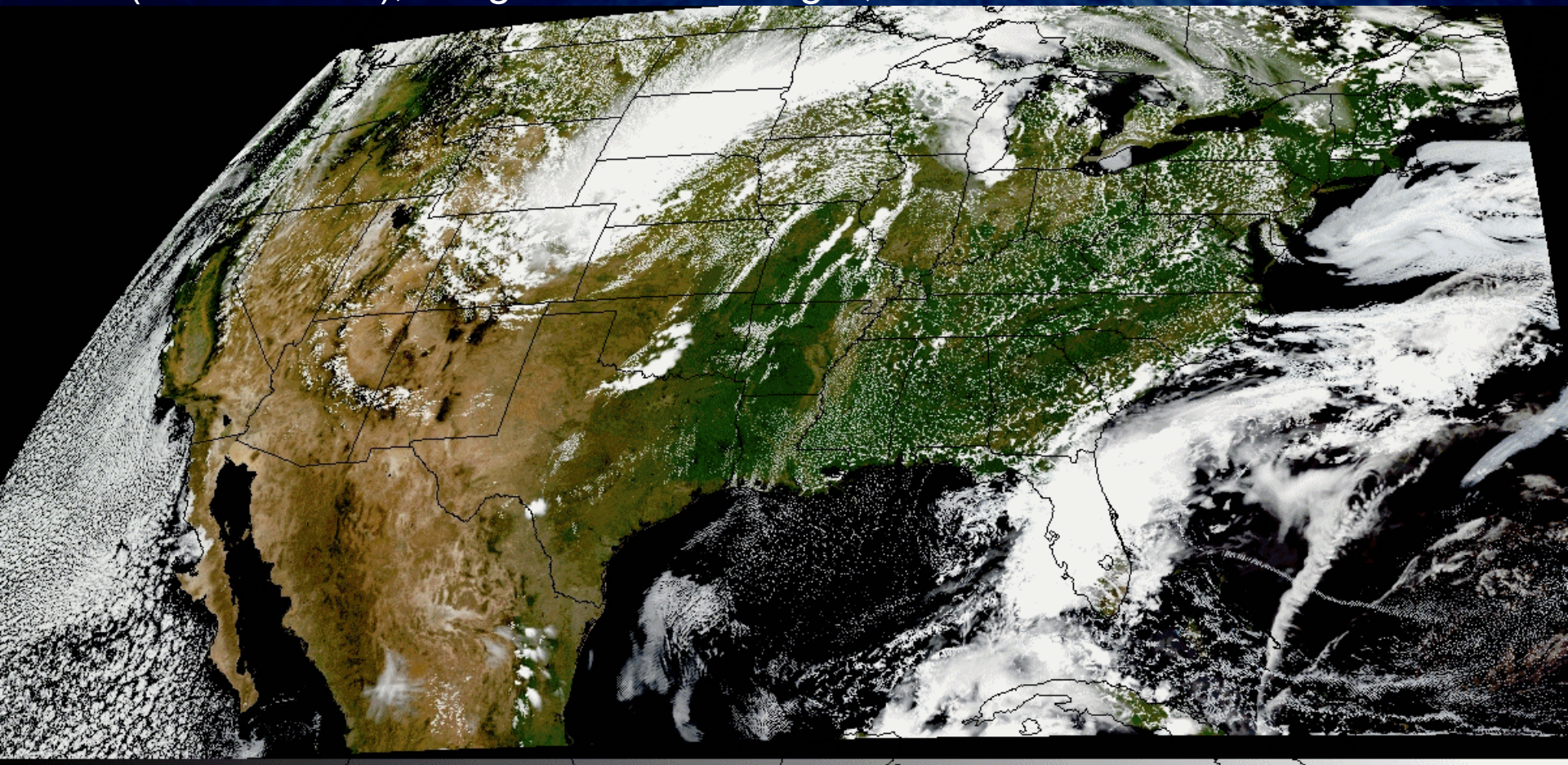
- Annual patch temperature changes may become more of an issue with future GOES due to fewer data outages.



In 2002 and before, the patch (detector) temperature increases were started while taking data. This had a large adverse effect on the data and products. Now the main temperature increases/impact are during normal outages.

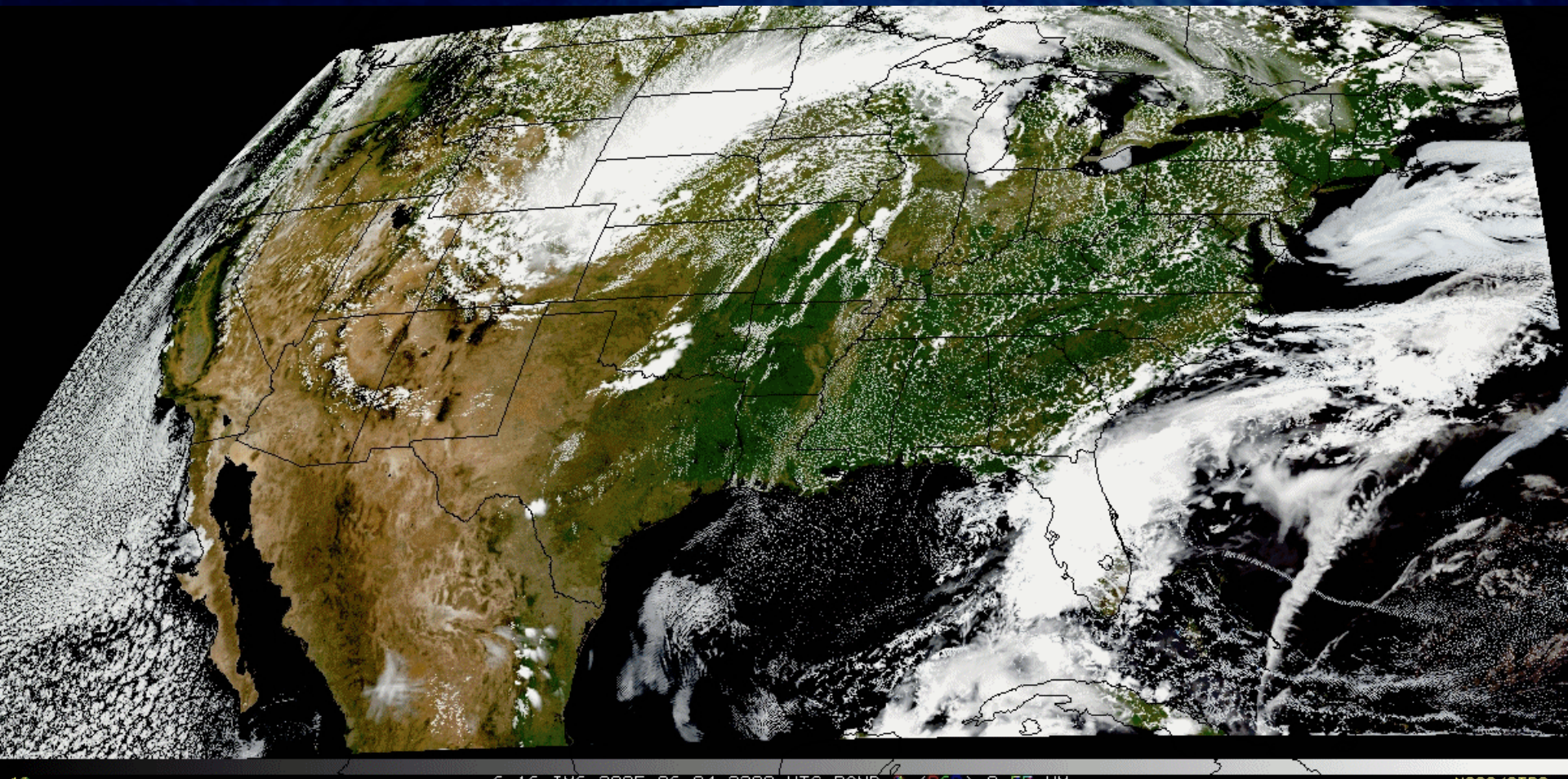
Validation – image combination

- "True Color" with "synthetic" green band from ABI simulated data (from CIMSS); image from Don Hillger, RAMMB.



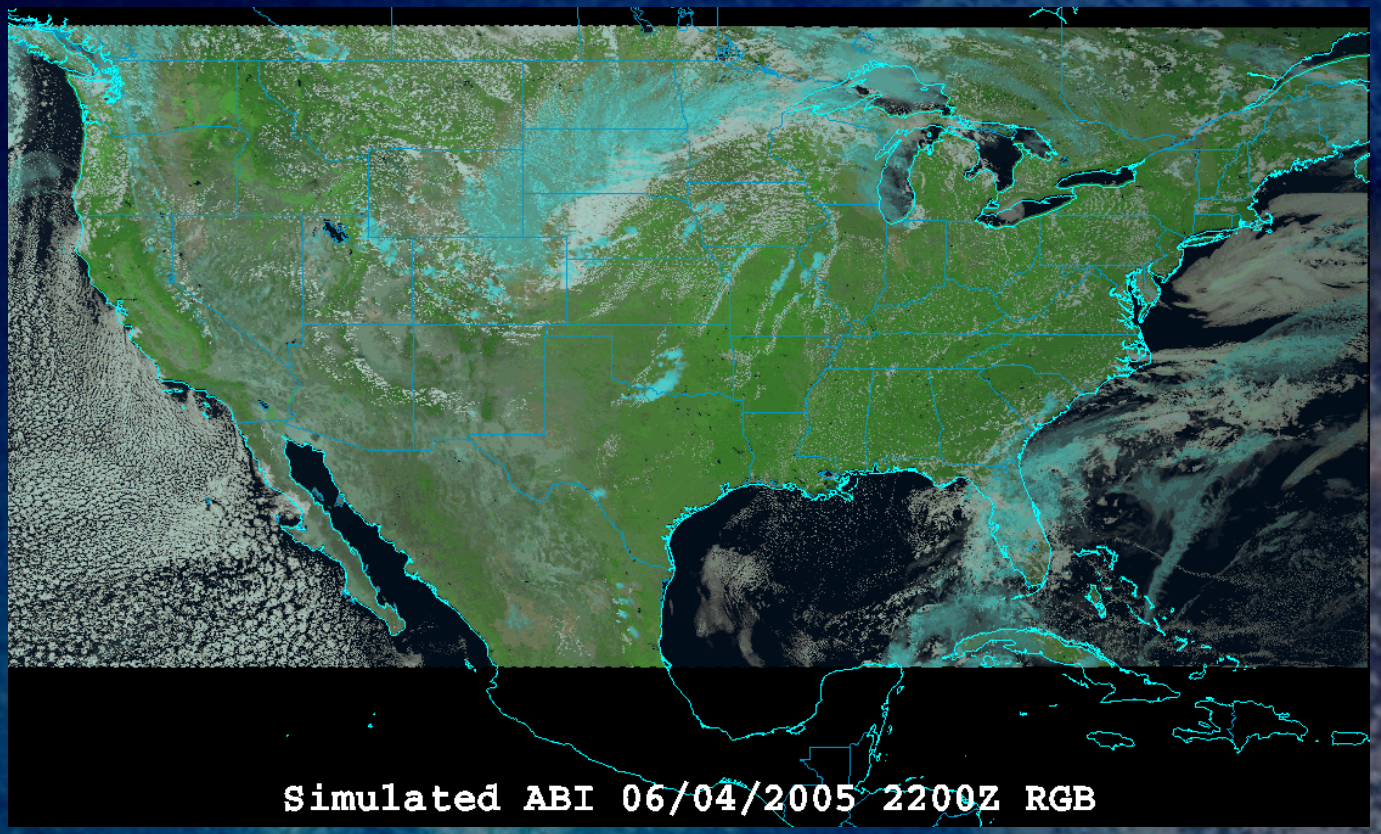
Validation – image combination movie

- "True Color" with "synthetic" green band *movie* from ABI simulated data (from CIMSS); image from Don Hillger, RAMMB.



Validation – image combination

- "RGB Color" (VIS 0.6, VIS 0.8, and NearIR 1.6 um) with ABI simulated data (from CIMSS); image from William Straka, CIMSS and using the EUMETSAT enhancement.

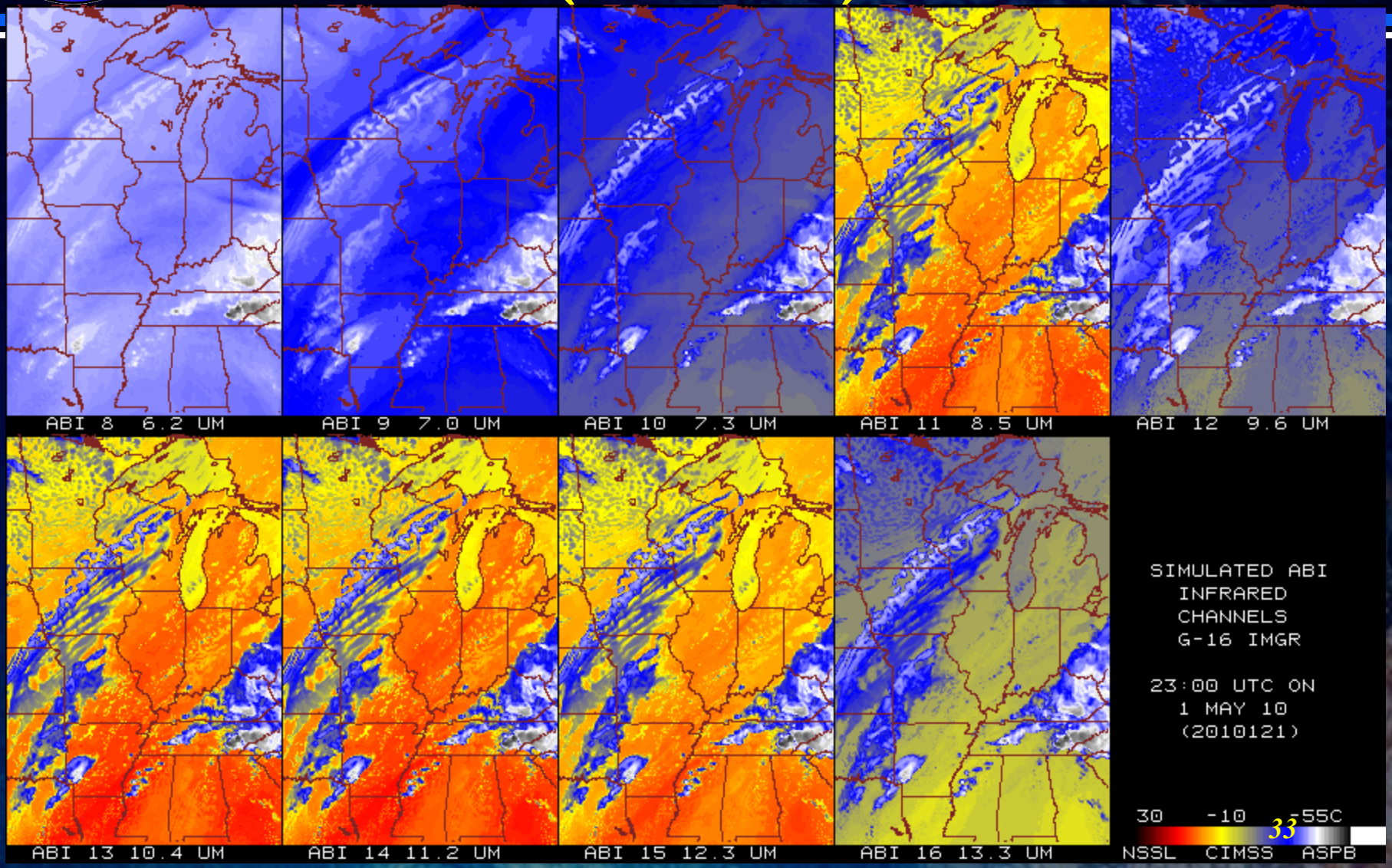


"Deep-Dive" Validation Tools

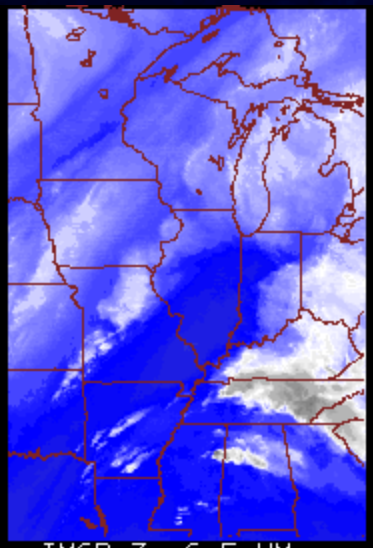
- This tool set includes, but is not limited to:
  - Additional Thumbnail images
  - Full size and/or zoomed images
  - Generate difference images
    - Temporal
    - Spectral
  - Times series of radiances/brightness temperatures
    - Longer time-series
  - Statistics of radiances/brightness temperatures
    - Longer times series
  - "Forward Model Calc" vs "Satellite Obs" information
    - From raobs, NWP, etc.
  - Correlate image artifacts with calibration events
  - Etc.
- McIDAS + scripts

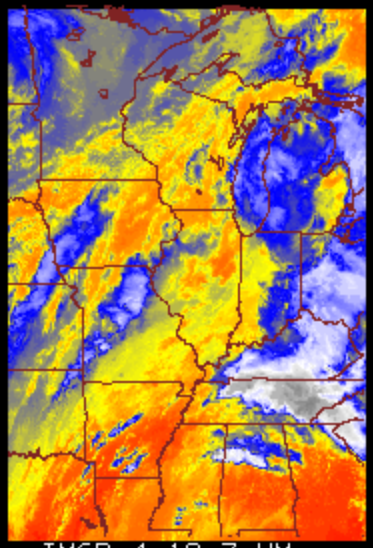
Calculated ABI bands (subset)

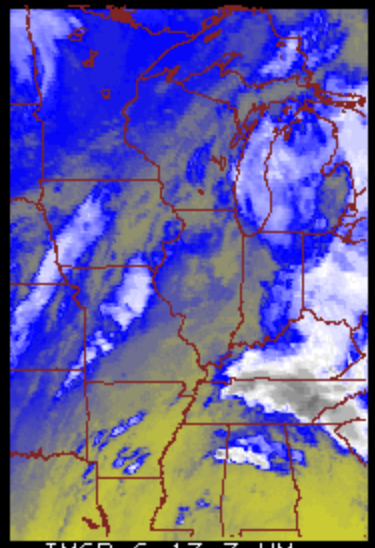
From NSSL WRF



Observed GOES-13 Imager





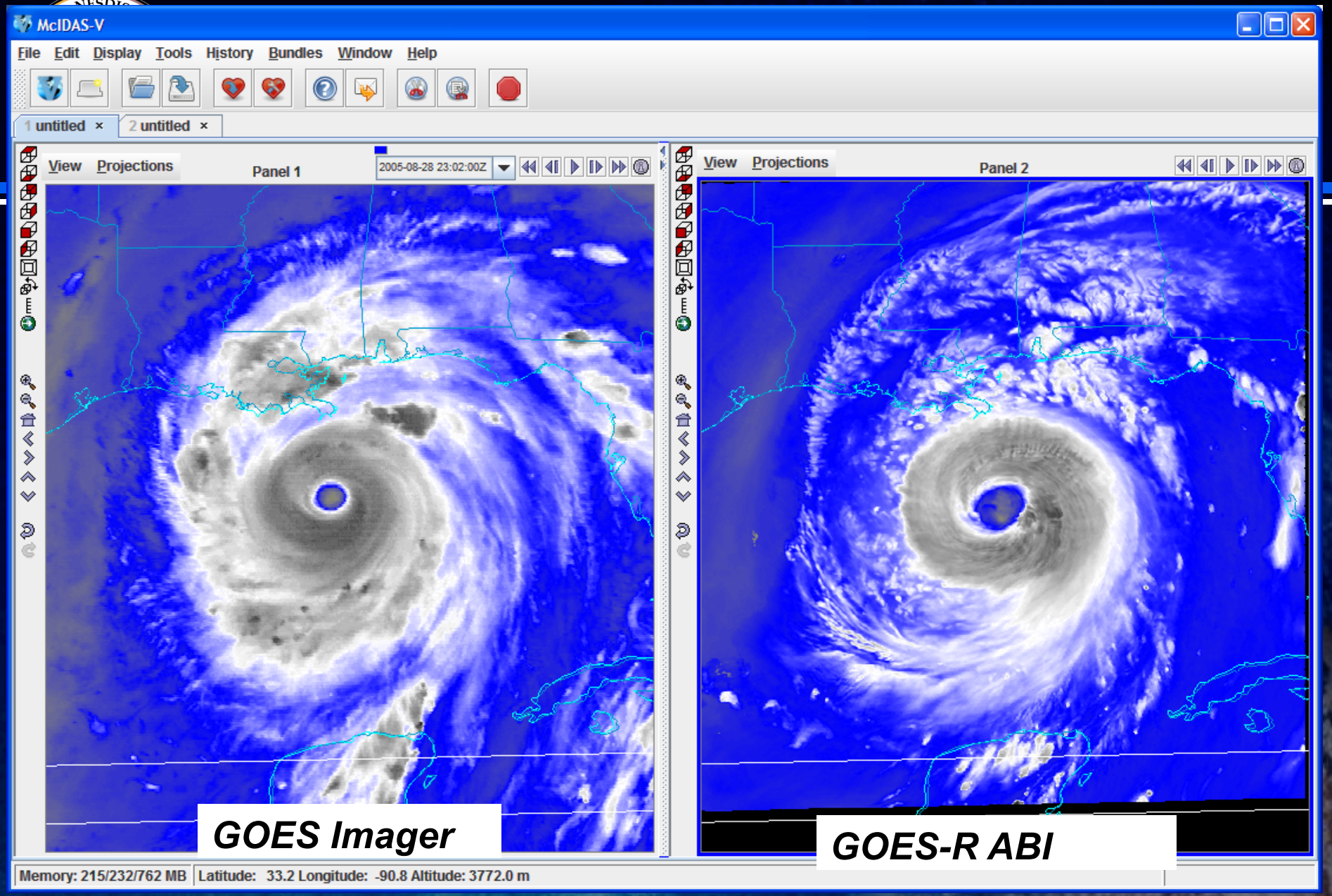


REMAPPED

INFRARED
CHANNELS
G-13 IMGR

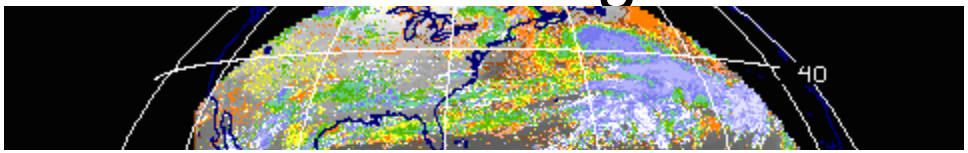
23:03 UTC ON
1 MAY 10
(2010121)

30 -10 -55C
UW CIMSS ASPB

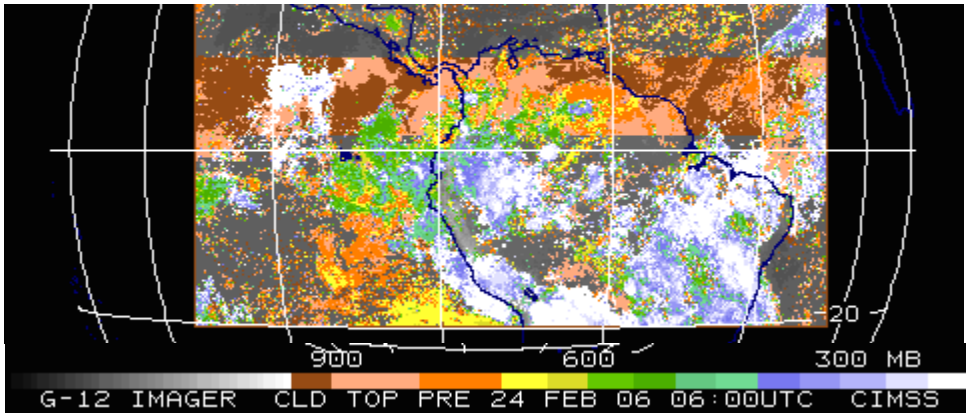


One is from a McIDAS AREA, while the other (simulated image) is from a netCDF.[35]

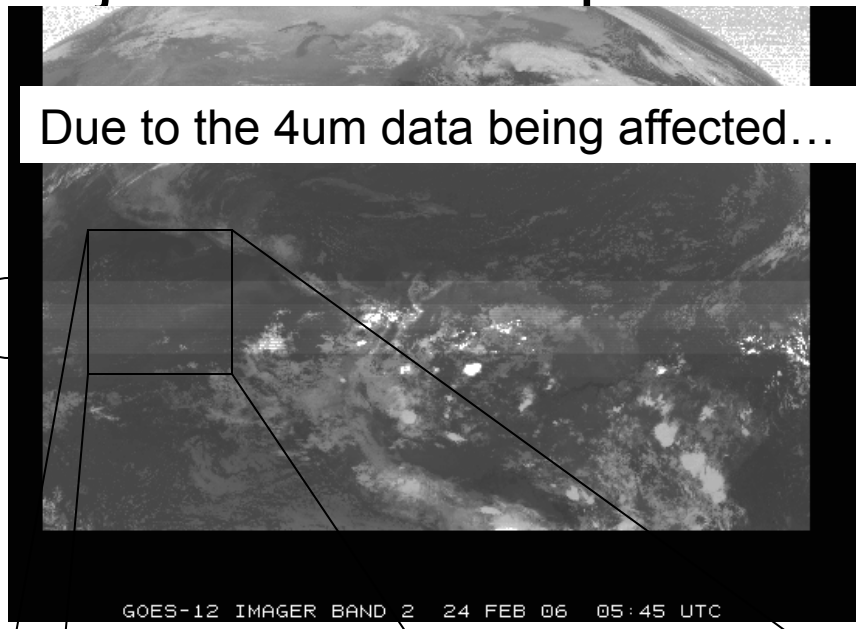
GOES-12 Imager 4 um band just before eclipse



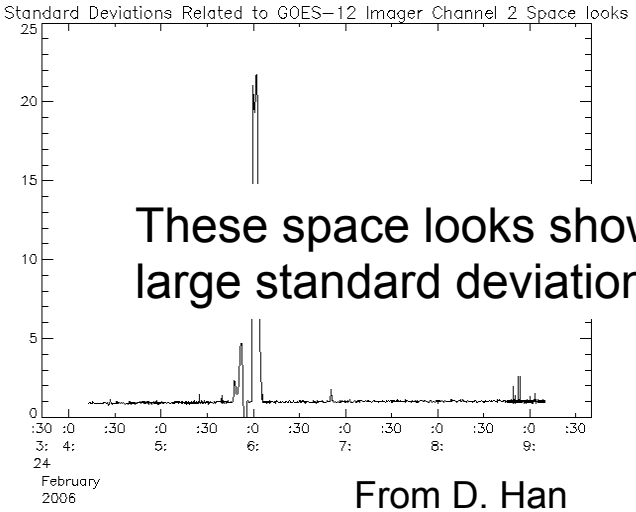
Imager Cloud-top pressure product affected…



Due to the 4um data being affected…



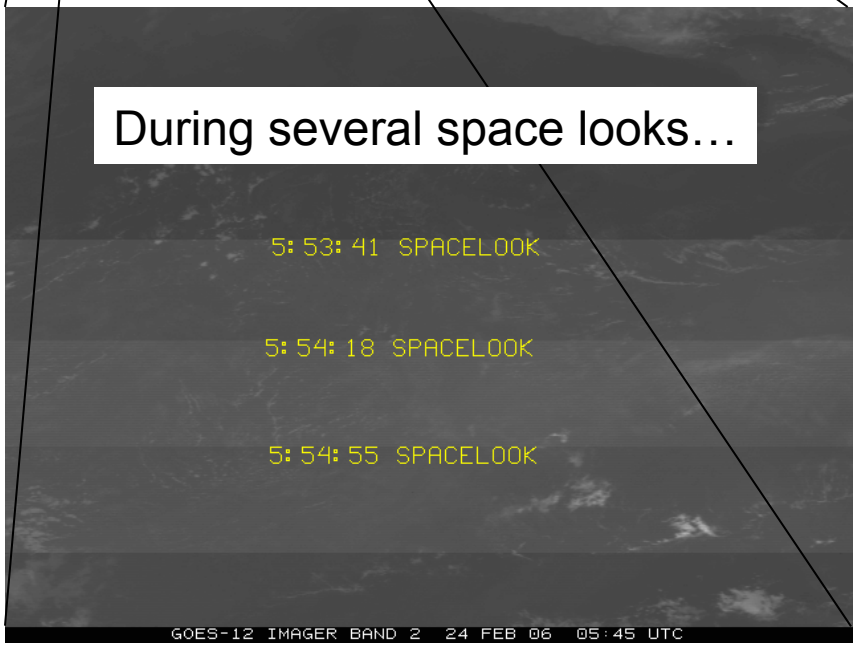
A GOES (Geostationary Operational Environmental Satellite) Incident Report (GIR) was submitted.

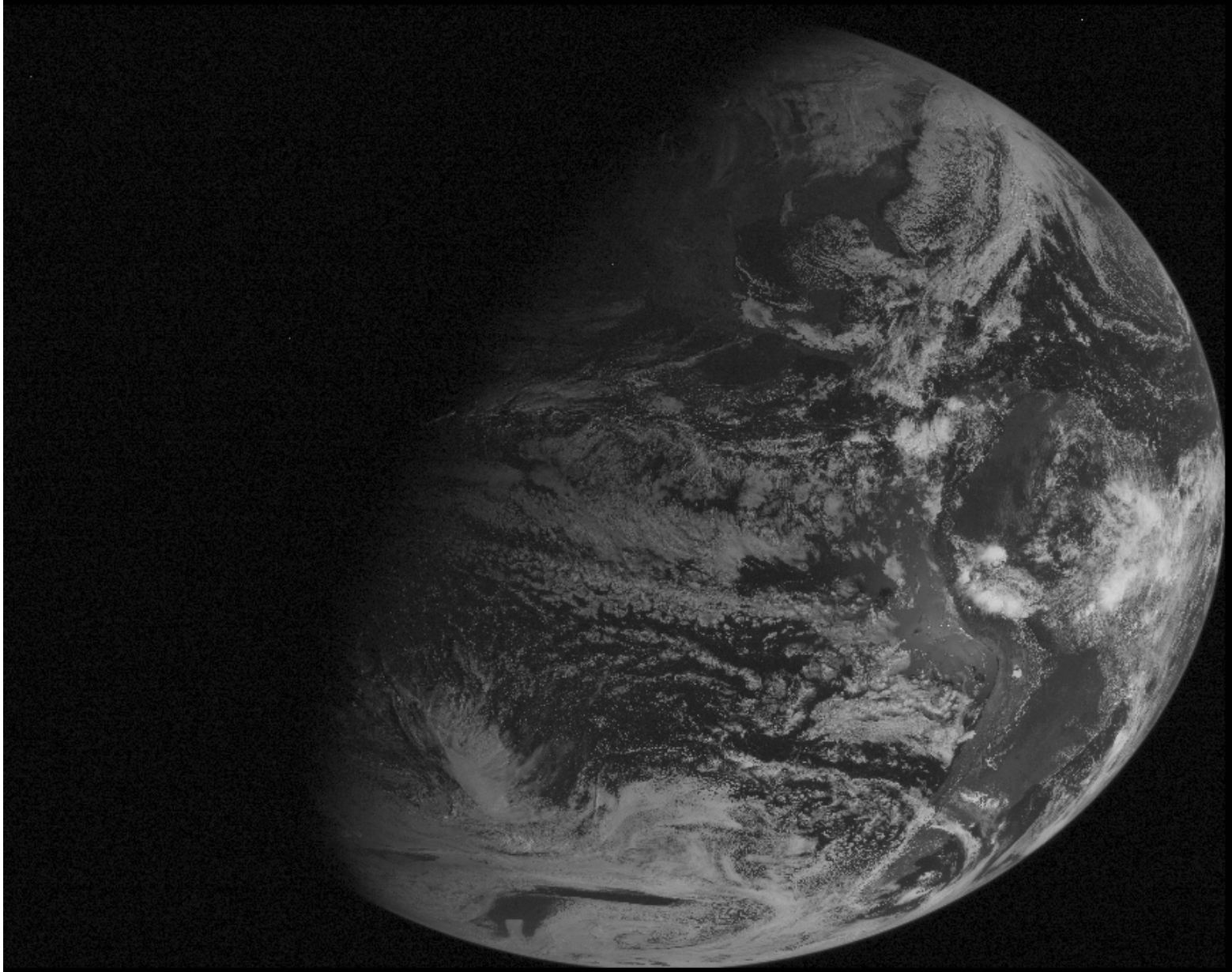


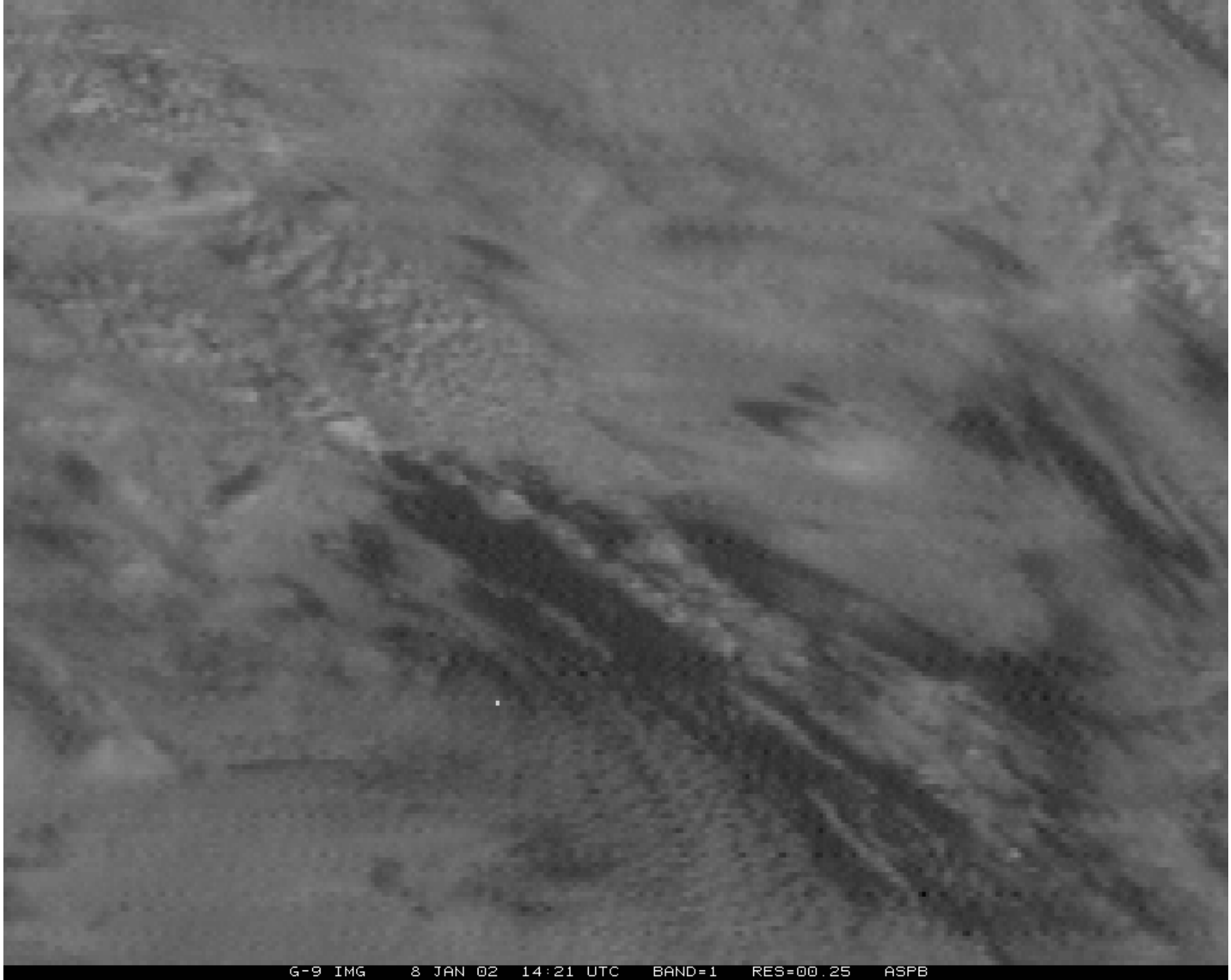
These space looks showed large standard deviations.

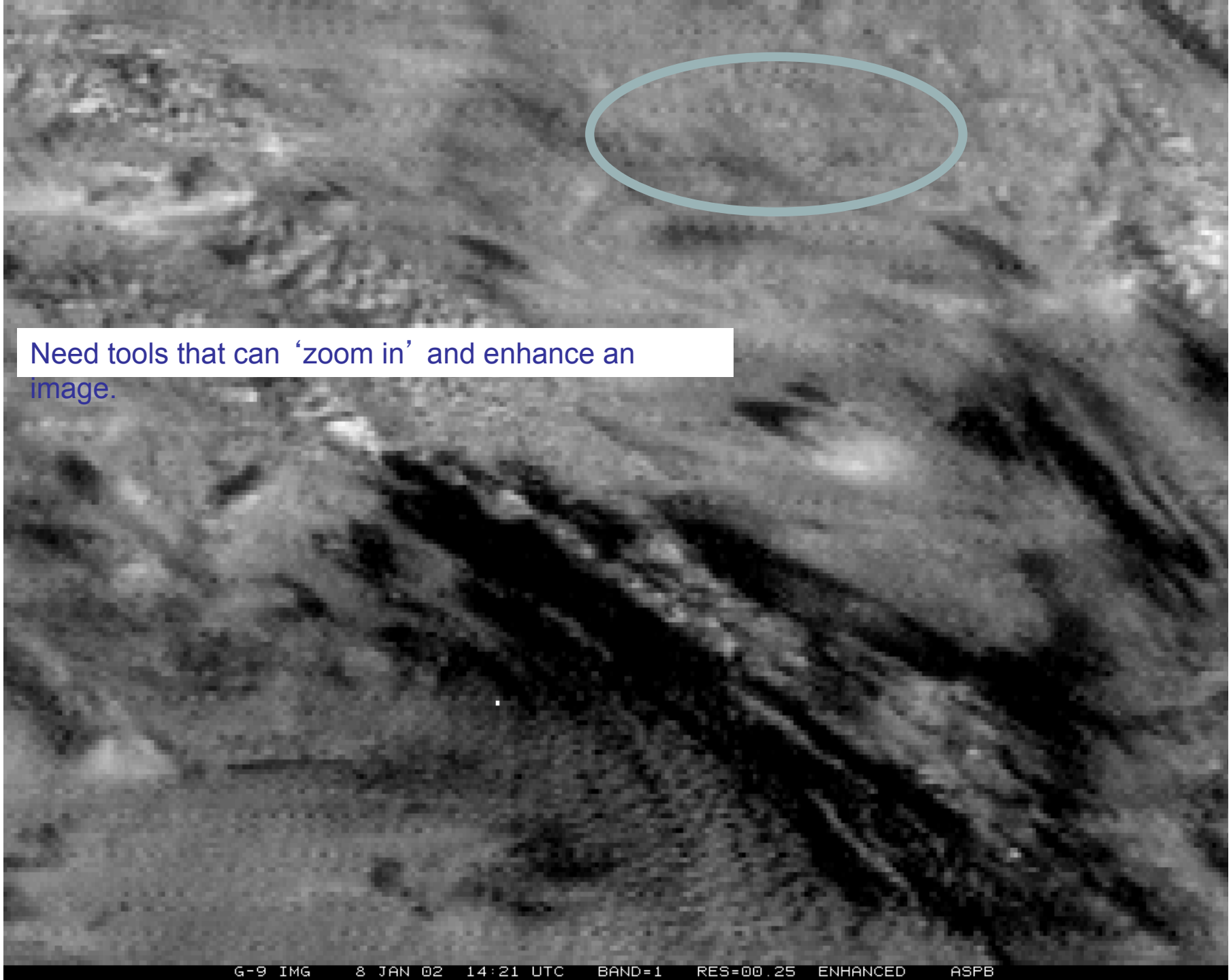
From D. Han

During several space looks…

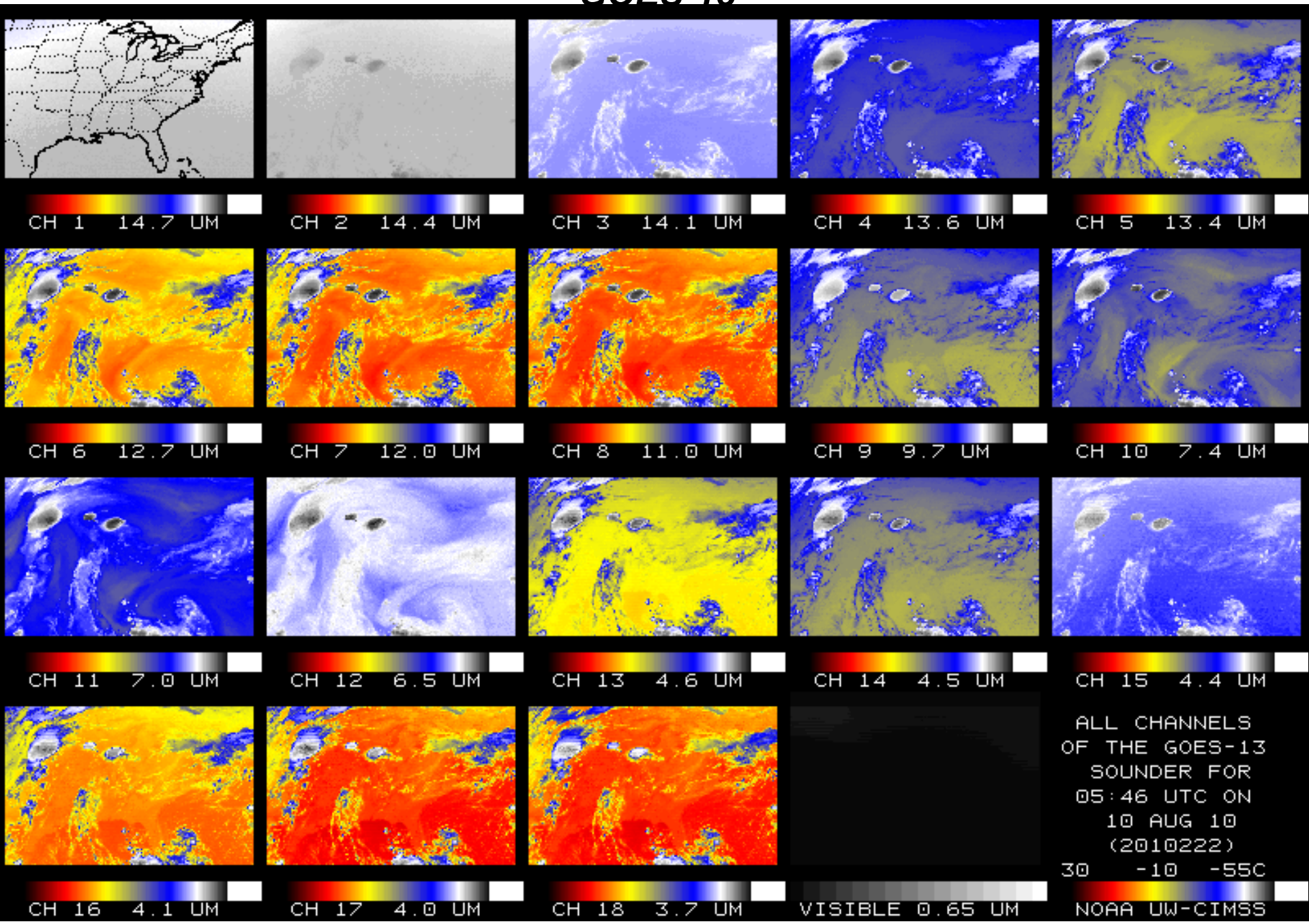



G-9 IMG 8 JAN 02 14:21 UTC BAND=1 RES=16.00 ASPB

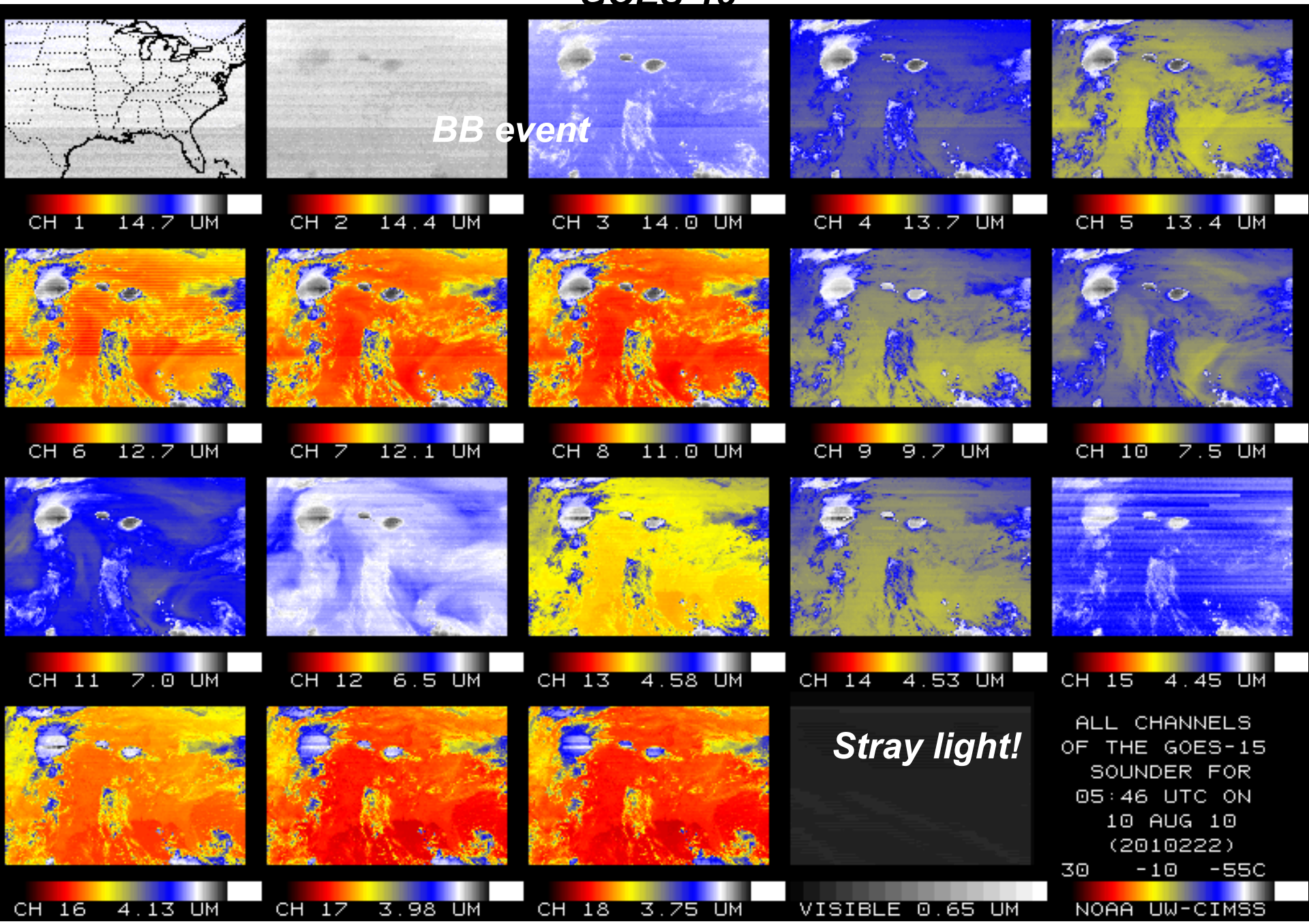

G-9 IMG 8 JAN 02 14:21 UTC BAND=1 RES=00.25 ASPB


Need tools that can ‘zoom in’ and enhance an image.
G-9 IMG 8 JAN 02 14:21 UTC BAND=1 RES=00.25 ENHANCED ASPB

GOES-13

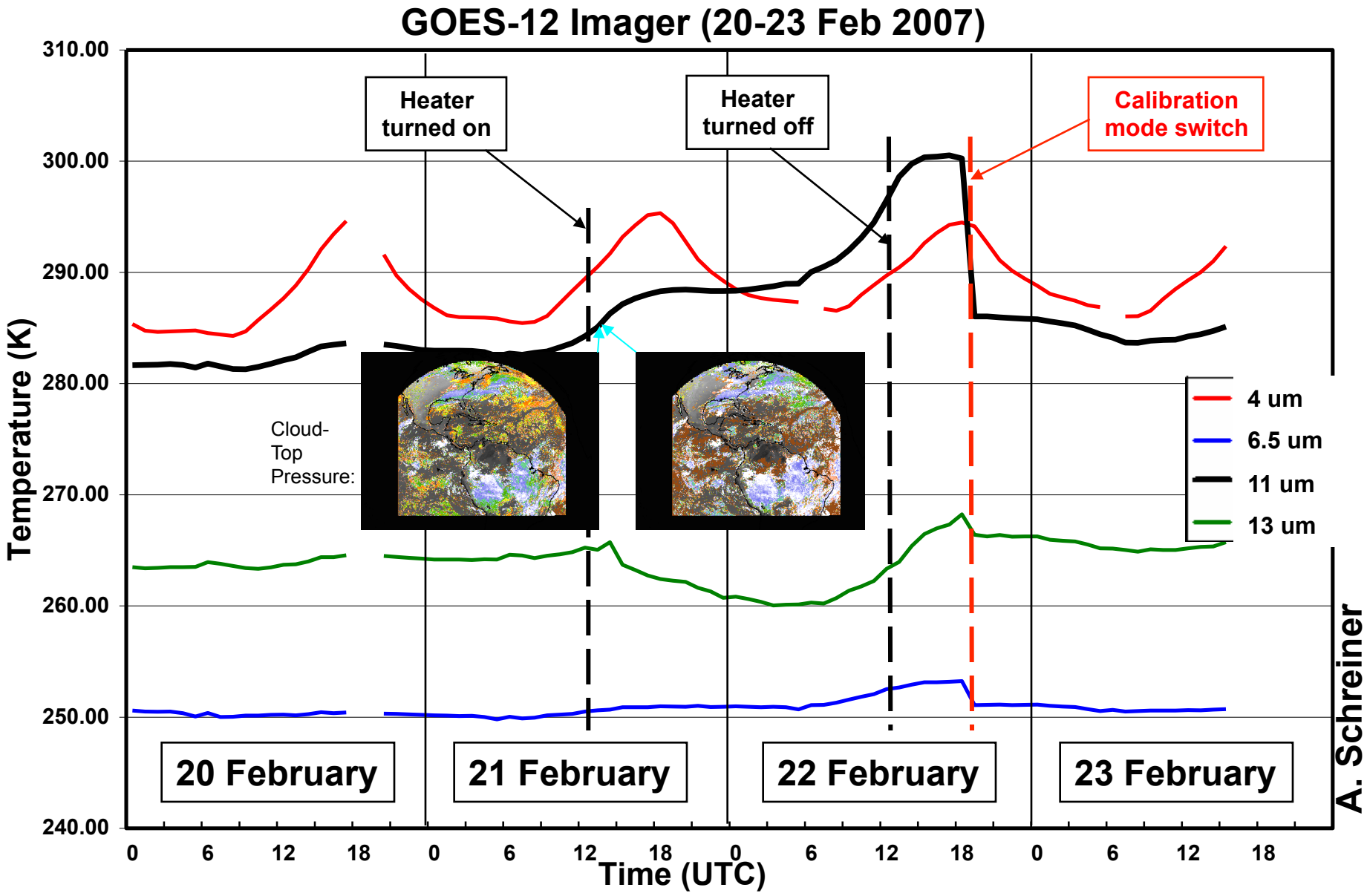

CH 1 14.7 UM
CH 2 14.4 UM
CH 3 14.1 UM
CH 4 13.6 UM
CH 5 13.4 UM
CH 6 12.7 UM
CH 7 12.0 UM
CH 8 11.0 UM
CH 9 9.7 UM
CH 10 7.4 UM
CH 11 7.0 UM
CH 12 6.5 UM
CH 13 4.6 UM
CH 14 4.5 UM
CH 15 4.4 UM
ALL CHANNELS
OF THE GOES-13
SOUNDER FOR
05:46 UTC ON
10 AUG 10
(2010222)
30 -10 -55C
CH 16 4.1 UM
CH 17 4.0 UM
CH 18 3.7 UM
VISIBLE 0.65 UM
NOAA UW-CIMSS

GOES-15


BB event
CH 1 14.7 UM
CH 2 14.4 UM
CH 3 14.0 UM
CH 4 13.7 UM
CH 5 13.4 UM
CH 6 12.7 UM
CH 7 12.1 UM
CH 8 11.0 UM
CH 9 9.7 UM
CH 10 7.5 UM
CH 11 7.0 UM
CH 12 6.5 UM
CH 13 4.58 UM
CH 14 4.53 UM
CH 15 4.45 UM
Stray light!
ALL CHANNELS
OF THE GOES-15
SOUNDER FOR
05:46 UTC ON
10 AUG 10
(2010222)
30 -10 -55C
CH 16 4.13 UM
CH 17 3.98 UM
CH 18 3.75 UM
VISIBLE 0.65 UM
NOAA UW-CIMSS

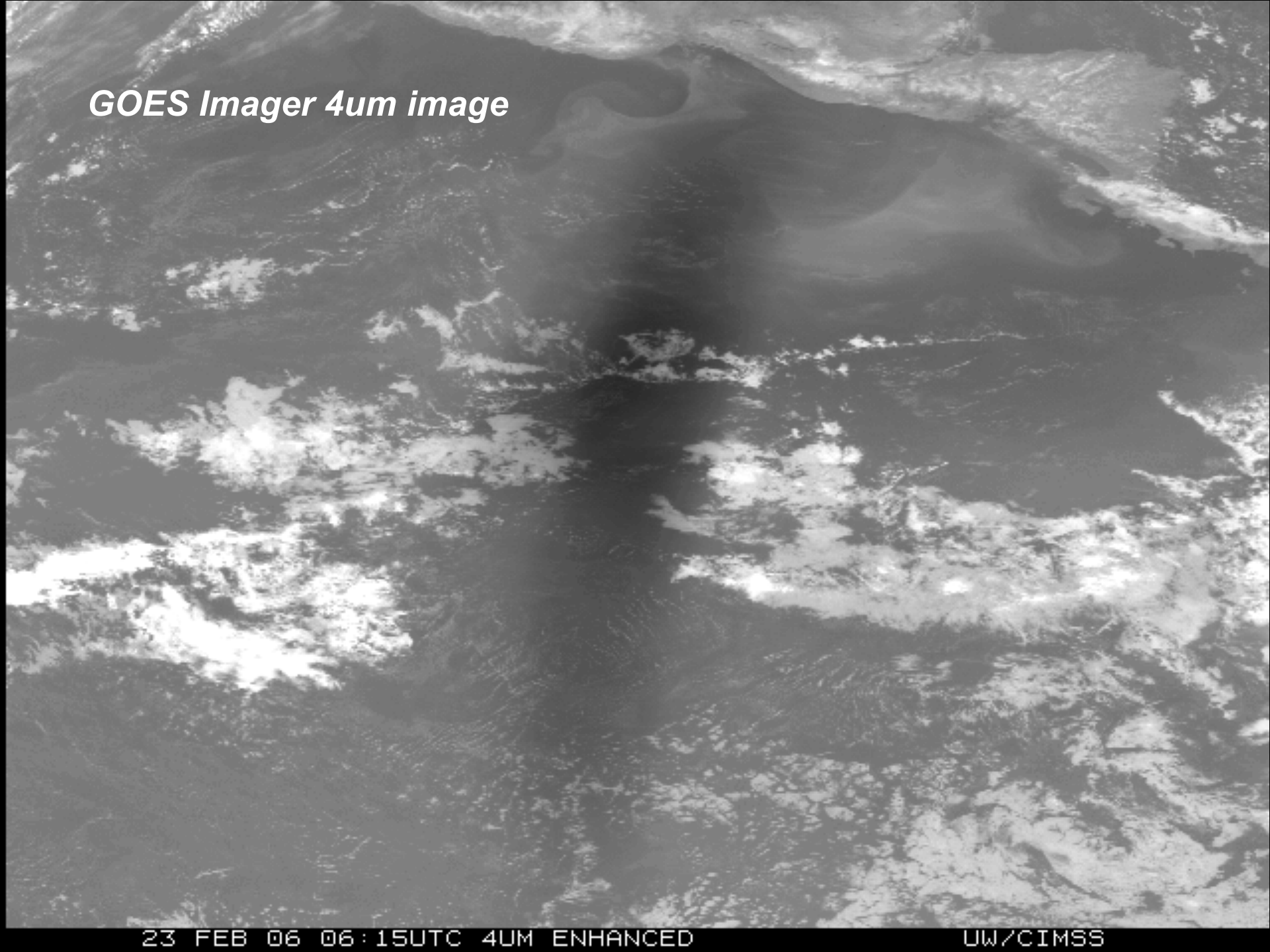
Ideas for the Further Enhancement and Utility of Validation Tools

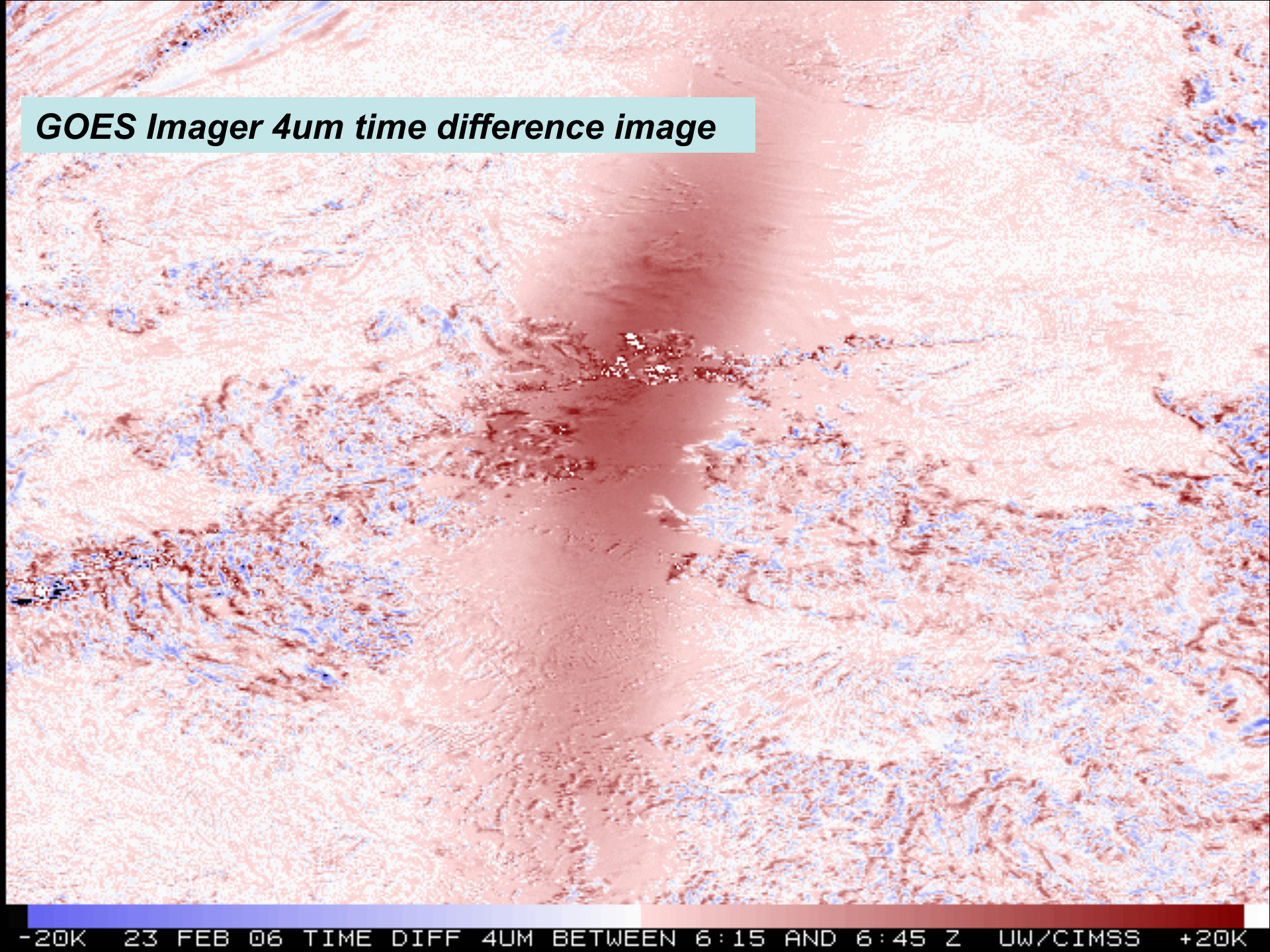
- Comparison to other satellites
  - Other images, Imagery correlations
  - High-spectral resolution IR sounders
- Radiance Quality assessment
  - Signal-to-noise ratio
  - Striping
  - INR
  - Forward model “calc” vs “obs”
  - Etc.
- Product generation is a good check on the input values!
- Hard to know the dividing line between imagery and calibration and/or system monitoring tools

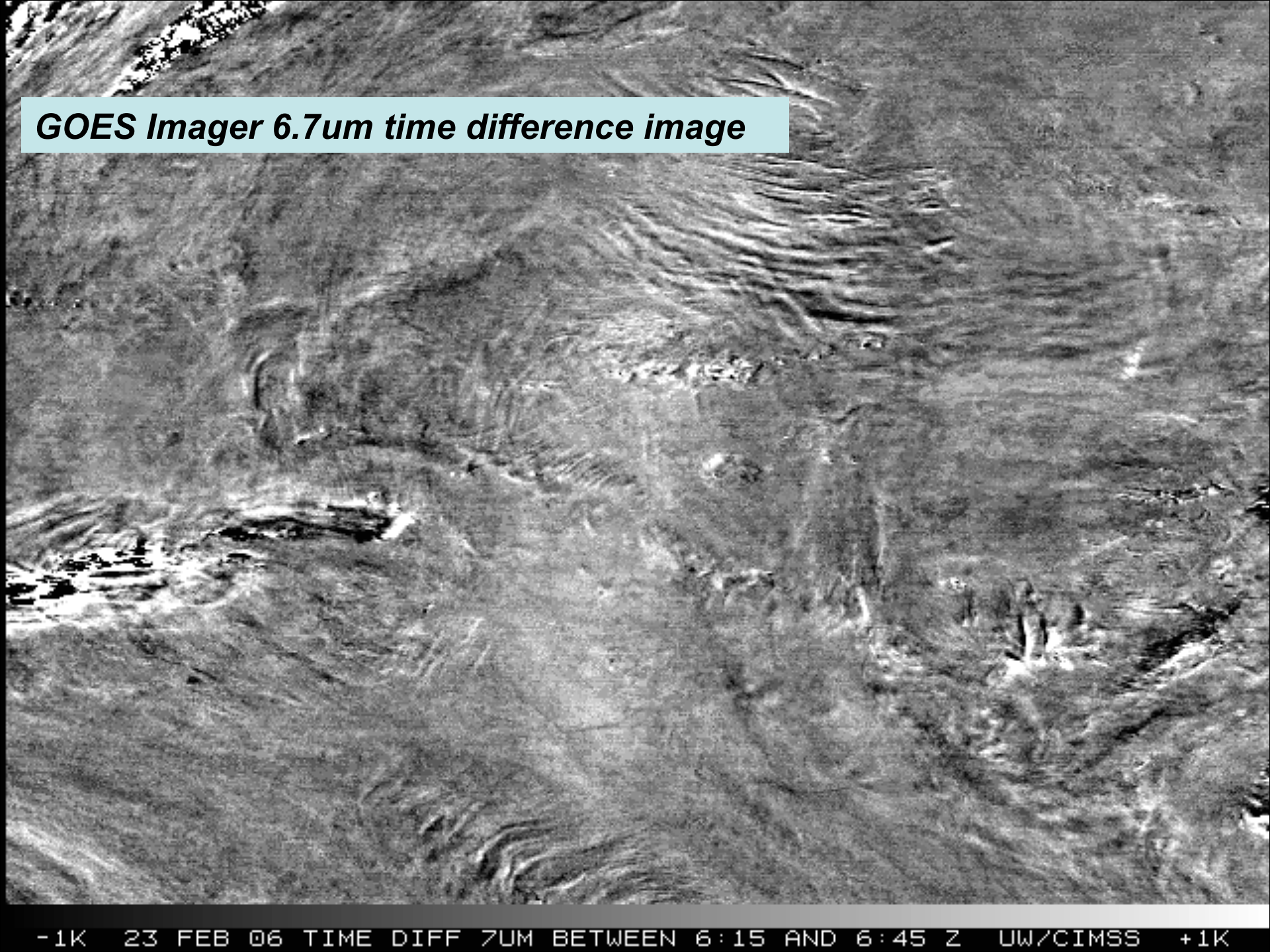


Note large change (100s hPa) of the retrieved cloud-top pressure heights and cloud mask in the images. Users were not notified before the heater was turned on.

GOES Imager Visible at night


GOES Imager 4um image
23 FEB 06 06:15UTC 4UM ENHANCED
UW/CIMSS


GOES Imager 4um time difference image
-20K 23 FEB 06 TIME DIFF 4UM BETWEEN 6:15 AND 6:45 Z UW/CIMSS +20K


GOES Imager 6.7um time difference image
-1K 23 FEB 06 TIME DIFF 7UM BETWEEN 6:15 AND 6:45 Z UW/CIMSS +1K


CIMSS Realtime GOES Derived Product Imagery - Mozilla Firefox
File Edit View History Bookmarks Tools Help
http://cimss.ssec.wisc.edu/goes/rt/sounder-dpi.php
Google
Most Visited http://www.osdpd.noaa...
CIMSS Realtime GOES Derive...
CIMSS GOES Realtime Derived Products
Sounder DPI
CIMSS
GOES Home
Home
Sounder DPI
Precipitable Water
Full GOES-E/W
Cont. US (GW/GE)
Cont. US - Low Layer
Cont. US - Mid Layer
Cont. US - Upper Layer
GOES-15
Cont. US w/ RAOB
Severe wx comparison
Sounder data (text)
Lifted Index
Cont. US (GW/GE)
GOES-15
Cont. US w/ RAOB
Severe wx comparison
CAPE
Cont. US
Cloud Products
Full GOES-E/W CTP
Cont. US CTP (GW/GE)
GOES-15
Cont. US ECA
Cloud data (text)
Total Column Ozone
US
DPI GIF Archive
Archive directory
All band display
GOES East
GOES West
GOES-15
GOES E/W Single Band
Band 3 (14.1µm)
Band 5 (13.4µm)
Band 8 (11.0µm)
Band 8 (GOES-15)
Band 10 (7.5µm)
Band 11 (7.0µm)
Band 12 (6.5µm)
Sounder DPI
Precipitable Water
Compare
Click on links below to view a product
Full GOES-East/West Coverage
Conterminous US - Total (GOES-W/E)
Conterminous US - Low Layer (GOES-W/E)
Conterminous US - Mid Layer (GOES-W/E)
Conterminous US - Upper Layer (GOES-W/E)
Conterminous US (GOES-15)
Conterminous US with RAOB
Comparison with reported severe weather
Sounder PW listings in text format
Lifted Index
Conterminous US (GOES-W/E)
Conterminous US (GOES-15)
Conterminous US with RAOB
Comparison w/ reported severe weather
CAPE
Conterminous US
Cloud Products
Full GOES-East/West Coverage CTP
CTP Conterminous US (GOES-W/E)
CTP Conterminous US (GOES-15)
ECA Conterminous US (GOES-W/E)
GOES Sounder Cloud Properties (text)
Clear
display
Compare
Click on links below to view a product
GOES East
GOES West
GOES-15
GOES E/W Conterminous US Single Band Composite Images
Band 3 (14.1 µm)
Band 5 (13.4 µm)
Band 8 (11.0 µm)
Band 8 (GOES-15)
Band 10 (7.4 µm)
Band 11 (7.0 µm)
Band 12 (6.5 µm)
Band 15 (4.4 µm)
Band 15 (GOES-15)
Band 17 (4.0 µm)
Band 19 (0.70 µm)
Band 19 (GOES-15)
Wisconsin DPI
GOES PW DPI/guess/RAOB
GOES LI DPI/guess/RAOB
GOES PW/LI/CTP w/ Vis/IR
Ozone
Full GOES-East/West Coverage
DPI GIF Archive
Archive of GOES Sounder derived products
Clear
Find:
Next
Previous
Highlight all
Match case
http://cimss.ssec.wisc.edu/goes/rt/viewdata.php?product=lisr_us

CIMSS Realtime GOES Derived Product Imagery - Mozilla Firefox

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http://cimss.ssec.wisc.edu/goes/rt/viewdata.php?product=compare

Most Visited http://www.osdpd.noaa...

CIMSS Realtime GOES Derive...

CIMSS GOES Realtime Derived Products

Compare

Full screen

Home

Sounder DPI

Precipitable Water
- Full GOES-E/W
- Cont. US (GW/GE)
- Cont. US - Low Layer
- Cont. US - Mid Layer
- Cont. US - Upper Layer
- GOES-15
- Cont. US w/ RAOB
- Severe wx comparison
- Sounder data (text)

Lifted Index
- Cont. US (GW/GE)
- GOES-15
- Cont. US w/ RAOB
- Severe wx comparison

CAPE
- Cont. US

Cloud Products
- Full GOES-E/W CTP
- Cont. US CTP (GW/GE)
- GOES-15
- Cont. US ECA
- Cloud data (text)

Total Column Ozone
- US

DPI GIF Archive
- Archive directory

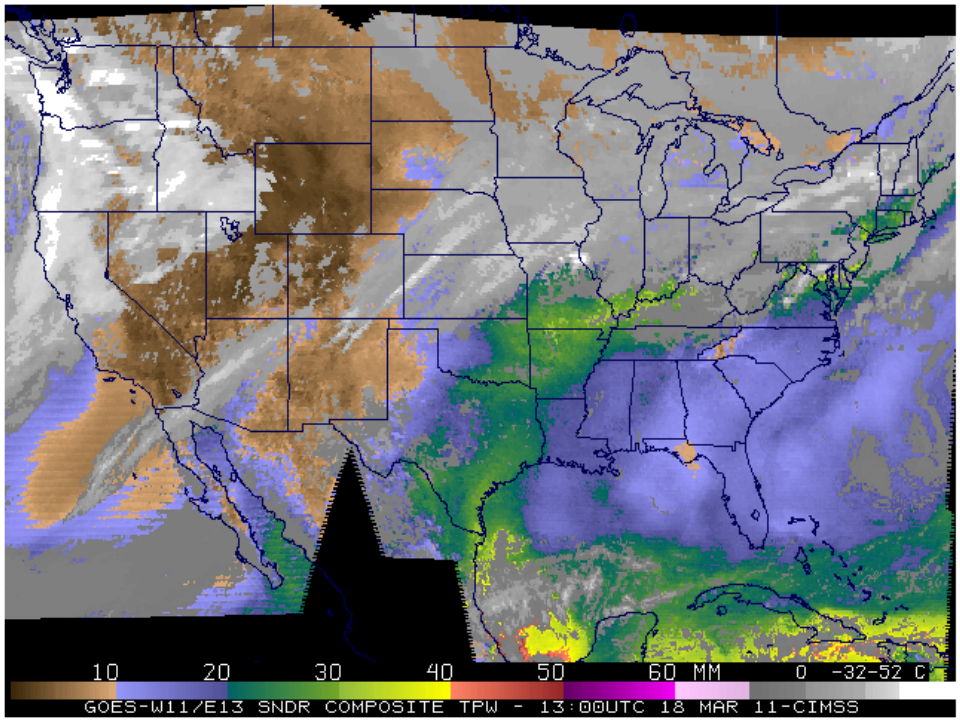
All band display
- GOES East
- GOES West
- GOES-15

GOES E/W Single Band
- Band 3 (14.1μm)
- Band 5 (13.4μm)
- Band 8 (11.0μm)
- Band 8 (GOES-15)
- Band 10 (7.5μm)
- Band 11 (7.0μm)

Latest | Toggle | Fader | Panel

Start | Show | Set Animation Speed | < | > | Zoom | Refresh

Left click - toggle on/off; Right click - show frame



× Find: Next Previous Highlight all Match case

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Precipitable Water
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Lifted Index
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- Cont. US w/ RAOB
- Severe wx comparison

CAPE
- Cont. US

Cloud Products
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- GOES-15
- Cont. US ECA
- Cloud data (text)

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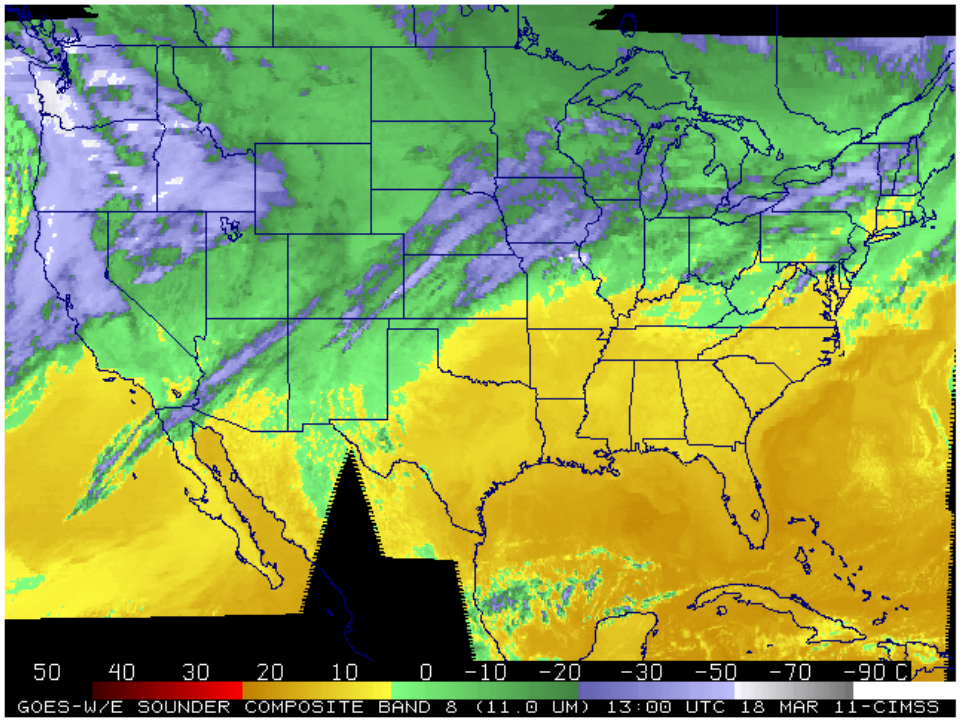
- Band 8 (11.0μm)
- Band 8 (GOES-15)
- Band 10 (7.5μm)
- Band 11 (7.0μm)

Latest | (•) Toggle | ( ) Fader | ( ) Panel

Start | Show | Set Animation Speed | < | > | Zoom | Refresh

Left click - toggle on/off; Right click - show frame



× Find: Next Previous Highlight all Match case

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File Edit View History Bookmarks Tools Help

http://cimss.ssec.wisc.edu/goes/rt/viewdata.php?product=compare&

Most Visited http://www.osdpd.noaa...

CIMSS Realtime GOES Derive...

CIMSS GOES Realtime Derived Products

Compare

Full screen

Home

Sounder DPI

Precipitable Water
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- Cont. US w/ RAOB
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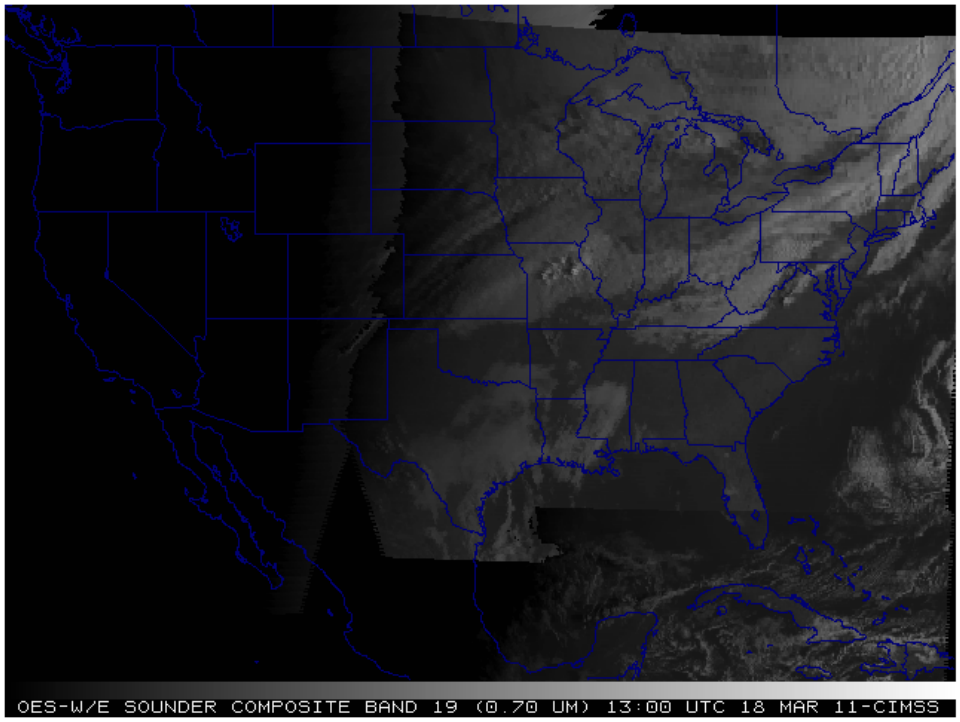
- Band 11 (7.0µm)

Latest | (•) Toggle | ( ) Fader | ( ) Panel

Start | Show | Set Animation Speed | < | > | Zoom | Refresh

Left click - toggle on/off; Right click - show frame

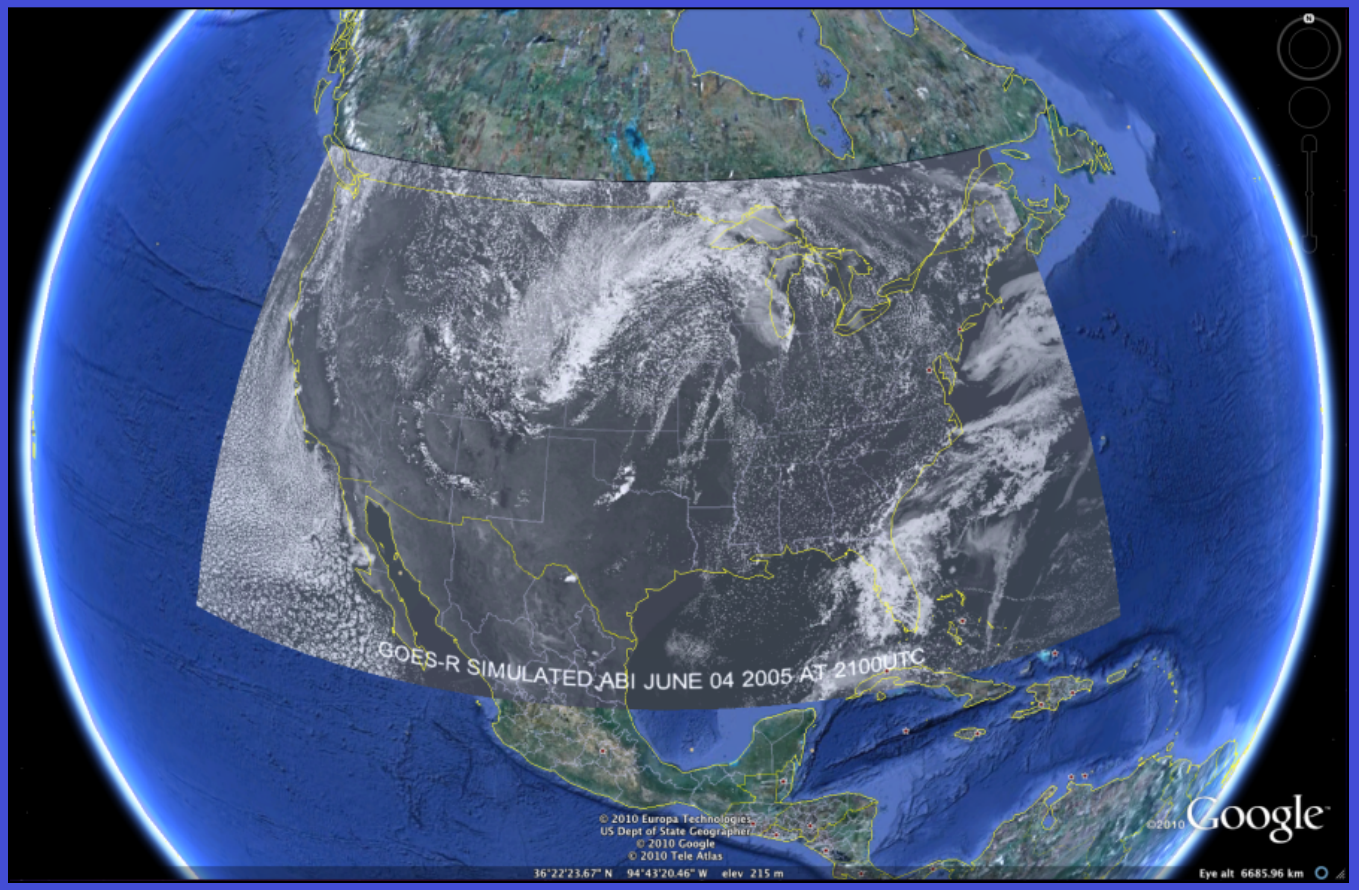


× Find: Next Previous Highlight all Match case

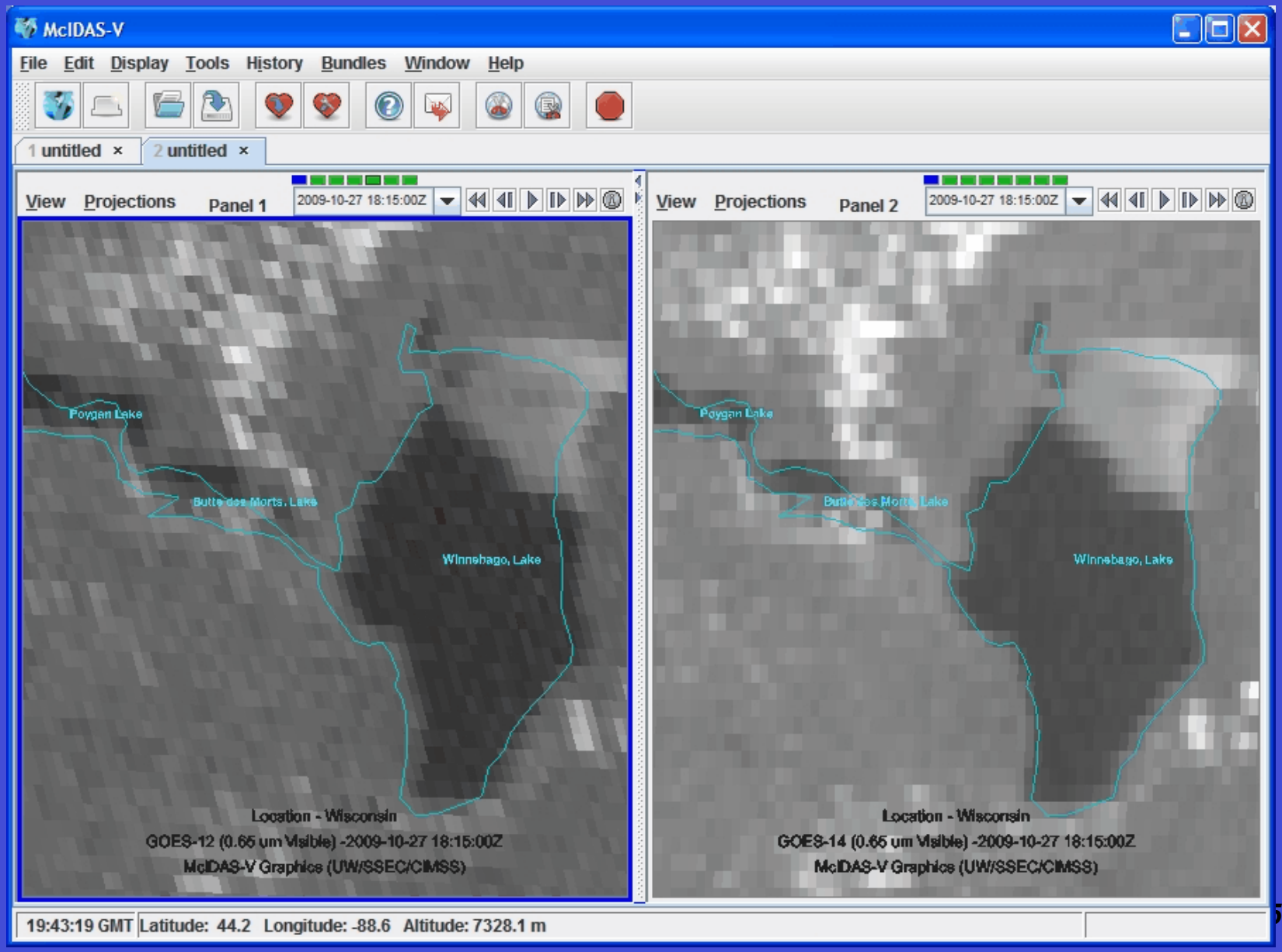
Loaded 100%

Google Earth

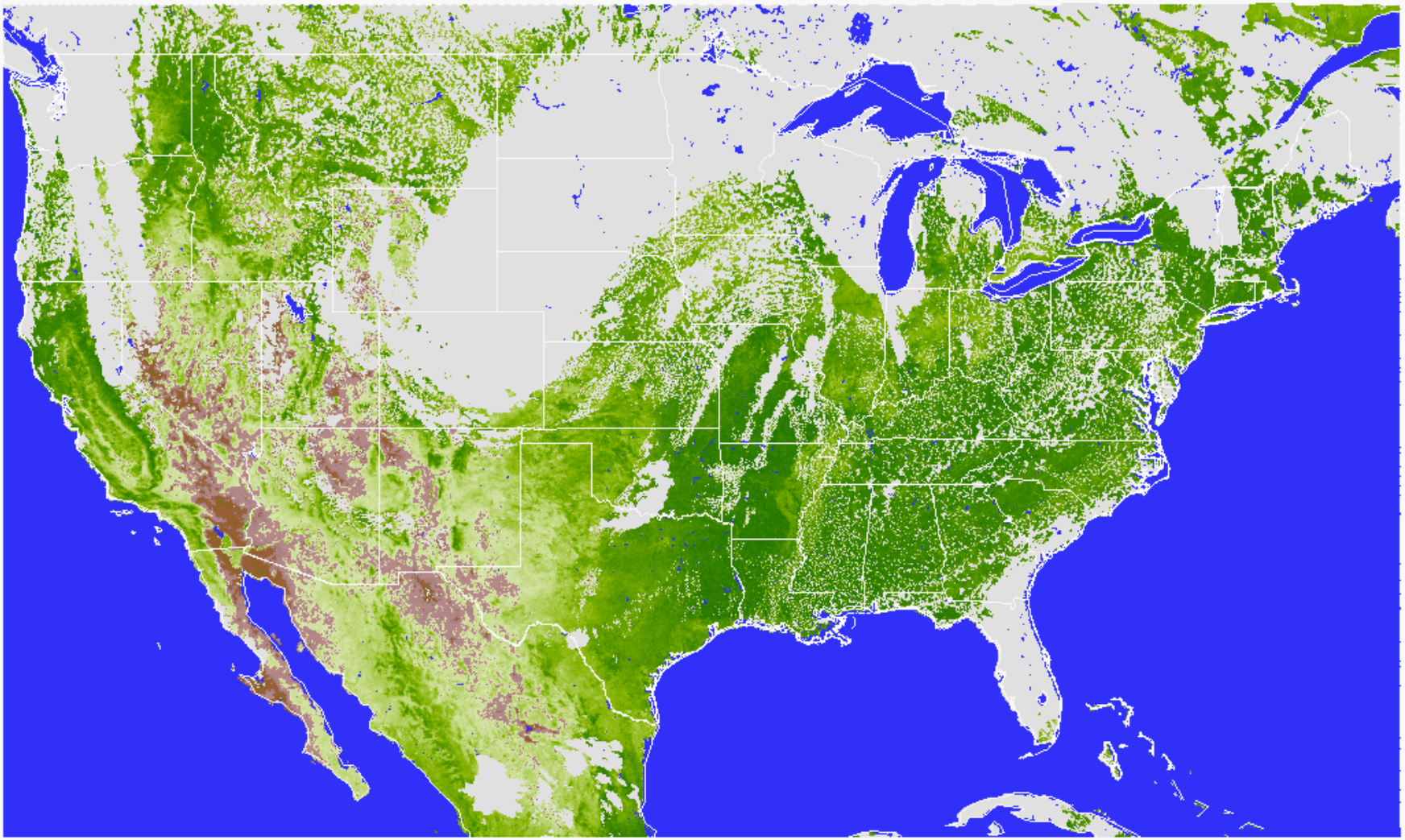
- Consider other formats, such as google earth:
  - http://cimss.ssec.wisc.edu/goes/abi/loops/links.html
  - GOES-R Advanced Baseline Imager (ABI) Band 2 shown



Animations


McIDAS-V
File Edit Display Tools History Bundles Window Help
1 untitled
2 untitled
View Projections Panel 1
2009-10-27 18:15:00Z
Poygan Lake
Winnebago, Lake
Location - Wisconsin
GOES-12 (0.65 um Visible) -2009-10-27 18:15:00Z
McIDAS-V Graphics (UW/SSEC/CIMSS)
View Projections Panel 2
2009-10-27 18:15:00Z
Poygan Lake
Winnebago, Lake
Location - Wisconsin
GOES-14 (0.65 um Visible) -2009-10-27 18:15:00Z
McIDAS-V Graphics (UW/SSEC/CIMSS)
19:43:19 GMT Latitude: 44.2 Longitude: -88.6 Altitude: 7328.1 m

Simulated ABI NDVI : June-04-2005, 2200utc



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NDVI

0.10 0.23 0.37 0.50 0.63 0.77 0.90

Summary

- Imagery is the key product and hence needs a sufficient validation tool set.
- This tool set should at least include:
  - Thumbnail images
  - Full size and/or zoomed images
  - Animations
  - Times series of radiances/brightness temperatures
  - Statistics of radiances/brightness temperatures
  - Temporal difference images
  - Spectral band differences
  - Combine images
  - Product generation!
  - Forward model “Calc” vs “Obs” information
  - Etc.
- Need a flexible system, which allows zooming, roaming, specialized enhancements, etc.
  - Hope for the best, plan for the worst.
- NOAA Science Tests Tech Reports for the GOES (lead by Hillger and Schmit)
  - http://rammb.cira.colostate.edu/projects/goes-o/